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A COMPENSATED OPTICAL STORAGE MEDIUM

Field of the invention

The present invention relates to an optical storage medium comprising a non-transparent bearing substrate and more specifically to an optical storage medium comprising at least one information surface supporting definition of at least a first nano-structure representing information in digital form. Furthermore the invention relates to a method for making said optical storage medium and the use of processes for making the optical storage medium.

Background of the invention

Generally optical storage media are known. Examples of optical storage media are Compact Discs (CD) and Digital Versatile Discs (DVD). The media comprises a bearing substrate on which a nano-structure representing information in digital form is provided on a first surface of the disc. The digital information is read from a second opposite side of the disc and thus the bearing substrate is transparent. The transparent material is a plastic material often polycarbonate.

In order to improve the reflection of a laser beam transmitted through the bearing substrate from the second side to the first side comprising the nano-structure, the nano-structure is provided with a reflective layer. It is critical for the media that the bearing substrate is transparent, as a laser beam can not be transmitted through a non-transparent substrate. On top of the reflective layer is often applied a lacquer. On the lacquer is often applied a colour print containing information about the media, such as the name of an artist and titles of e.g. the songs of the record.

As the bearing substrate is made of a transparent material any kind of light, e.g. day light or a laser beam, is transmitted through the substrate. A known property of plastic substrates is that the substrate deteriorate when exposed to UV light and thus over time the quality of the disc decrease resulting in a disc which can not be read by e.g. a compact disc player or a CD-ROM drive. As optical storage media are also used for storing information, it is desired that the disc is readable over time especially for archives comprising information which must be accessible for decades.

Due to the deteriorating nature of known optical storage media institutions storing information such as libraries, national archives etc. are reluctant to use the optical storage media. Thus the information storing institutions fail to obtain the advantages of the space saving media.

Furthermore, in order to increase primarily the reading speed in current optical storage technology, such as in CD-ROM drives, etc., rotational speed of disc formed optical storage media is increased. However, present optical storage media are typically formed in a brittle polymeric material so that the disc, such as a CD-ROM tends to shatter when exposed to the induced centrifugal forces at these increased speeds.

Description of the invention

It is the object of the present invention to provide an optical storage medium which overcomes the above mentioned disadvantages.

It is an object of the present invention to provide an optical storage medium capable of withstanding high centrifugal forces stemming from correspondingly high rotation speeds of the medium.

The above and other aspects are fulfilled by an optical storage medium comprising at least one information surface supporting definition of at least a first nano-structure representing information in digital form, the optical storage medium further comprising a substrate comprising a substantially non-transparent material.

The optical storage medium may comprise one information surface e.g. when the medium is a Compact Disc or a CD-ROM, but the medium may also comprise a plurality of information surfaces such as two, such as three, such as four, such as five, such as six, such as seven, such as eight, such as nine, such as ten. The information surfaces may be provided side by side or on top of each other e.g. separated by layers such that the disc may comprise a multi-layer structure of information surfaces, e.g. such that the disc may be used as e.g. a DVD or a DVD-ROM. The information surfaces may extend in the same direction and/or be provided in the same plane, but could also be provided in planes being transverse to each other, e.g. the angel between at least a part of two planes may be 5 degrees, or 10 degrees, or 15 degrees or 20 degrees, or 30 degrees, or 40 degrees.

Each information surface may comprise one nano-structure but could also comprise a plurality of nano-structures dividing the information surface in to a plurality of zones. The information surface may comprise two nano-structures, or three nano-structures, or four nano-structures, or five nano-structures, or six nano-structures, or seven nano-structures or eight nano-structures, or nine nano-structures. Some nano-structures may comprise information in digital form, while others are adapted to support definition of information in digital form. Some of the nano-structures may be changed once by application of an electromagnetic field and/or by an electromagnetic wave e.g. a laser beam while others may be changed a plurality of times.

The substrate is preferably substantially non-transparent and thus substantially no light is transmitted through the substrate. The substrate may be a bearing substrate, so that the desired stiffness of the optical storage medium is not provided if the said substrate is not present. Thus the optical storage medium may collapse or not comprise a needed stability if the substrate is not bearing. Alternatively, the substrate may be a supporting substrate for supporting the film layer(s) and compensating layer(s) without being bearing.

The optical storage medium may be round such as elliptic or circular but the medium may also be a polygon such as a triangle or a quadrangle or a polygon with five edges or six edges or seven edges or eight edges or nine edges or ten edges. The polygonal shaped

storage medium may have smooth edges e.g. such that the medium has substantially the same shape as a credit card or an access card. The optical storage medium may have the shape of a key-ring or a key for e.g. a door or any other shape.

In an embodiment the information surface may comprise a first nano-structure representing information in digital form. The information may be encoded but could also be non-encoded. The information may comprise an encoded part and a part comprising an algorithm for decoding the information. The decoding algorithm may be mpeg 1, such as mpeg 1 - layer 3 (mp3), mpeg 4 or any other algorithm for compressing information.

The information surface may make the optical storage medium recognisable for an optical detecting device. An optical detecting device may be a device comprising a light emitting means and a means for detecting a reflected light beam, such as a Compact Disc player, such as a Compact Disc recorder or a DVD-drive or a Laser disc or a DVD-player or a DVD-recorder or a CD-ROM drive or a DVD-ROM drive. The information surface may be recognisable due to information stored on said surface. The information may by information about tracks on the medium or could be information about the capacity of the optical storage medium.

In an embodiment the bearing substrate may comprise at least one metallic material, thus the bearing substrate in this embodiment is non-transparent and deterioration due to exposure to UV light is eliminated. In another embodiment the bearing substrate may be a non-metallic material selected from the group consisting of glass, polymers, elastomers, paper, cardboard, wood or any combination thereof. E.g. the glass may be coloured e.g. black such that it is non-transparent. Additionally a substrate comprising polymers or elastomers may comprise a colour such that light can not deteriorate the plastic material. In an embodiment the substrate is made of cardboard and thus the optical storage medium may be provided in e.g. an A4-shaped piece of cardboard for example by embossing the storage medium. The storage medium may for example be embossed such that a weakened line separates the optical storage medium from the rest of the cardboard. In another embodiment the cardboard is covered with structure supporting layer e.g. a lacquer on which the information surface is provided.

The optical storage medium may further comprise a second nano-structure supporting definition of the first nano-structure. The definition of said second nano-structure may be required for the optical storage medium to be recognisable for an optical detecting device. The information surface may comprise at least one geometrical structure supporting definition of the first nano-structure. The geometrical structure may be one track but could also be a plurality of tracks. The information surface may comprise a nano-structure comprising a plurality of pits, a pit being a point on the surface where the surface is elevated. The pits may be provided on the information surface such that they extend in the same direction so as to form a geometrical structure.

The geometrical structure may comprise a first zone defining a first nano-structure and/or a second zone defining the second nano-structure. The first nano-structure may be provided with a plurality of pits. A groove may be provided in the second nano-structure. The groove may support definition of a nano-structure representing information in digital form. The groove may be provided in the information surface. The information surface may be provided on one surface of the optical storage medium but could also be provided on two opposite sides of the storage medium.

The geometrical structure may form a helix, but the optical storage medium may also comprise a plurality of concentric geometrical structures. The information may be provided such that it should be read from centre of the medium and outwards, but could also be provided such that it should be read from the outer edge and inwards. The geometrical structure may be provided in structures extending radially on the optical storage medium.

The bearing substrate may comprise a first and an opposite second surface, at least one of said surfaces may comprise at least a one information surface. In one embodiment both the first and the second surfaces are information surfaces.

The optical storage medium may further comprise a first substrate having a first and a second surface, the first substrate being substantially parallel to a plane defined by the bearing substrate. In an embodiment at least a part of the first substrate may define a plane transverse to the bearing substrate such as defining an angle of 5 degrees, such as 10 degrees, such as 15 degrees, such as 20 degrees, such as 25 degrees, such as 30 degrees.

At least one of the first and the second surfaces of the first substrate may comprise at least one information surface. In an embodiment both the first and the second surface may be an information surface. The two information surfaces may constitute the two layers in an Digital Versatile Disc.

The optical storage medium may further comprise a second substrate having a first and a second surface, the second substrate being substantially parallel to a plane defined by the bearing substrate and/or the first substrate. In an embodiment at least a part of the second substrate may define a plane transverse to the bearing substrate and/or the first substrate such as defining an angle of 5 degrees, such as 10 degrees, such as 15 degrees, such as 20 degrees, such as 25 degrees, such as 30 degrees.

At least one of the first and the second surfaces of the second substrate may comprise at least one information surface. In an embodiment both the first and the second surfaces may be information surfaces.

The optical storage medium may further comprise a third substrate having a first and a second surface, the third substrate being substantially parallel to a plane defined by the bearing substrate and/or the first substrate and/or the second substrate. In an

embodiment at least a part of the third substrate may define a plane transverse to the bearing substrate and/or the first substrate and/or the second substrate such as defining an angle of 5 degrees, such as 10 degrees, such as 15 degrees, such as 20 degrees, such as 25 degrees, such as 30 degrees.

At least one of the first and the second surfaces of the third substrate may comprise at least one information surface. In an embodiment both the first and the second surfaces may be information surfaces.

The optical storage medium may further comprise a fourth substrate having a first and a second surface, the fourth substrate being substantially parallel to a plane defined by the bearing substrate and/or the first substrate and/or the second substrate and/or the third substrate. In an embodiment at least a part of the fourth substrate may define a plane transverse to the bearing substrate and/or the first substrate and/or the second substrate and/or the third substrate such as defining an angle of 5 degrees, such as 10 degrees, such as 15 degrees, such as 20 degrees, such as 25 degrees, such as 30 degrees.

At least one of the first and the second surfaces of the fourth substrate may comprise at least one information surface. In an embodiment both the first and the second surfaces may be information surfaces.

The optical storage medium may comprise further substrates such as a fifth substrate, such as a sixth substrate, such as a seventh substrate, such as an eighth substrate, such as a ninth substrate, such as a tenth substrate. Said substrates may comprise any of the features of the bearing substrate or the first, second, third or fourth substrate.

The bearing substrate may comprise a reflective surface providing the desired reflective properties. The reflective surface e.g. tin may have the reflective properties with or without being polished. At least a part of at least one information surface may be covered with a reflective layer. The layer or the reflective surface of the bearing substrate may reflect all light emitted to the surface but may also emit 90 %, such as 80 %, such as 70 %, such as 60 %, such as 50 %, such as 40 %, such as 30 %. The reflective layer may be a semi-reflective layer. As an example the semi-reflective layer may either reflect or transmit the majority of light emitted to the layer and thus absorb little of the light. In an embodiment the reflective layer may comprise a metallic material. The metallic material may be polished so as to enhance the reflective properties.

An information surface of the bearing substrate may be reflective. An information surface of the first, second, third or fourth substrate may also be reflective. In an embodiment a first layer may be reflective while another may be semi-reflective. The reflective layer may be

provided between the bearing substrate and the semi-reflective layer.

The optical storage medium may comprise a multi-layer structure provided on the first surface of the bearing substrate. In an embodiment a multi-layer structure may be provided on the second surface of the bearing substrate. Furthermore both the first and the second surface of the bearing substrate may be provided with a multi-layer structure.

The multi-layer structure may comprise the first substrate and/or the second substrate and/or the third substrate and/or the fourth substrate or any other additional substrates. In an embodiment the order of the substrates in the multi-layer from the bearing structure and outwards may be; first, second, third and fourth substrate. But the order of the substrates may also be any other, such as second, first, fourth and third substrate. In an embodiment with a multi-layer structure on the first and second surface of the bearing substrate, the order of the first, second, third and fourth substrates may be the same on both sides seen from the bearing substrate and outwards. In another embodiment the order may be different for the two multi-layer structures.

The multi-layer structure may comprise the first substrate, at least a part of said first substrate being connected to the surface on the bearing substrate on which the multi-layer structure is provided. Only a part of the first substrate may be connected to the bearing substrate but the whole substrate may also be connected to the bearing substrate.

The multi-layer structure may further comprise the second substrate, at least a part of said second substrate being connected to a surface of the first substrate. Only a part of the second substrate may be connected to the first substrate but the whole substrate may also be connected to the first substrate. In an embodiment a part of one side of the second substrate may be connected to the first substrate while a part of the same side of the second substrate is connected to the bearing substrate.

In an embodiment the multi-layer structure may further comprise the third substrate, at least a part of said third substrate being connected to a surface of the second substrate. Only a part of the third substrate may be connected to the second substrate but the whole substrate may also be connected to the second substrate. In an embodiment a part of one side of the third substrate may be connected to the second substrate while a part of the same side of the third substrate is connected to the first substrate, while yet another part of the same side of the third substrate is connected to the bearing substrate.

According to the invention the multi-layer structure may further comprise the fourth substrate, at least a part of said fourth substrate being connected to a surface of the third substrate. Only a part of the fourth substrate may be connected to the third substrate but the whole substrate may also be connected to the fourth substrate. In an embodiment a part of one side of the fourth substrate may be connected to the third substrate while a part of the same side of the fourth substrate is connected to the second substrate, while yet another part of the same side of the fourth substrate is connected to the first substrate, while a further part of the same side of the fourth substrate is connected to the bearing substrate.

The first side and/or the second side of the first and/or the second and/or the third and/or the fourth substrate may be provided with a lacquer and/or an information surface and/or a reflective layer and/or a transparent layer and/or a semi-transparent layer and/or a magnetic layer.

In an embodiment the propagation rate of an electromagnetic wave in the first substrate may be lower than the propagation rate of the electromagnetic wave in the second substrate, such as 10 percent lower, such as 20 percent lower, such as 30 percent lower, such as 40 percent lower, such as 50 percent lower, such as 60 percent lower, such as 70 percent lower, such as 80 percent lower, such as 100 percent lower or 200 percent lower.

The coefficient of reflection of the first substrate may be higher than the coefficient of reflection of the second substrate, such as 10 percentage points higher, such as 20 percentage points higher, such as 30 percentage points higher, such as 40 percentage points higher, such as 50 percentage points higher, such as 60 percentage points higher, such as 70 percentage points higher, such as 80 percentage points higher, such as 90 percentage points higher or vice versa.

The following formula could be used for the calculation of the difference in the focal point when changing from a CD made from polycarbonate to a CD made from a metal substrate.

The first parameter which must be known is the opening angle of the laser beam, which angle is the angle of the beam in relation to the surface of the CD. In the following, this angle is referred to as α_{air}. The angle is measured in relation to the axis of incidence.

The index of refraction of air n_{air} is set to 1. The index of polycarbonate n_{CD}=1.55.

1 $$n_{air}\sin(\alpha_{air}) = n_{CD}\sin(\alpha_{CD})$$

2 $$d_{air} = d_{CD}\frac{\tan(\alpha_{CD})}{\tan(\alpha_{air})}$$

The angle of incidence of the laser beam is 26,744 degrees.
If this value is inserted into the formula no. 1, an angle of 16,877 degrees inside the CD is calculated.

By using formula no. 2, it is possible to calculate how much the focal distance on the information surface of the CD is moved when the CD is replaced by air. If the angles and the thickness of the CD of 1,2 mm. dair=0,721 mm. is calculated.

The propagation rate of an electromagnetic wave in the second substrate may be lower than the propagation rate of the electromagnetic wave in the third substrate, such as 10 percent lower, such as 20 percent lower, such as 30 percent lower, such as 40 percent lower, such as 50 percent lower, such as 60 percent lower, such as 70 percent lower, such as 80 percent lower, such as 100 percent lower or 200 percent lower.

The coefficient of reflection of the second substrate may be higher than the coefficient of reflection of the third substrate, such as 10 percentage points higher, such as 20 percentage points higher, such as 30 percentage points higher, such as 40 percentage points higher, such as 50 percentage points higher, such as 60 percentage points higher, such as 70 percentage points higher, such as 80 percentage points higher, such as 90 percentage points higher or vice versa.

According to an embodiment of the present invention the propagation rate of an electromagnetic wave in the third substrate may be lower than the propagation rate of the electromagnetic wave in the fourth substrate, such as 10 percent, lower such as 20 percent lower, such as 30 percent lower, such as 40 percent lower, such as 50 percent lower, such as 60 percent lower, such as 70 percent lower, such as 80 percent lower, such as 100 percent lower or 200 percent lower.

The coefficient of reflection of the third substrate may be higher than the coefficient of reflection of the fourth substrate, such as 10 percentage points higher, such as 20 percentage points higher, such as 30 percentage points higher, such as 40 percentage points higher, such as 50 percentage points higher, such as 60 percentage points higher, such as 70 percentage points higher, such as 80 percentage points higher, such as 90 percentage points higher.

In an embodiment the first substrate and/or second substrate and/or the third substrate and/or the forth substrate may be a semi-transparent material.

Basically, electromagnetic radiation within the spectrum of light, is dampened in metal as in any other material, i.e. exponentially. The difference between metal and other materials is merely that the process occur much faster in metallic materials. Typical values for the thickness of a reflective surface can be estimated from the formula:

$$d = \frac{\lambda_0}{4\pi n_\kappa}$$

Wherein d is the layer thickness which dampens (reflects) the light $1/e \approx 0{,}37$, or, in other terms, wherein 63% of the light is transmitted. λ_0 is the wavelength of the laser light in vacuum (in this case, the value is substantially the same as for air), i.e. 780 nm. n_κ is a value which contains both the refractive index and the absorption coefficient for the

material. In the case of a sodium lamp, with the wavelength of 5893 Å (589,3 nm) the value is 2,83. It is for this purpose sufficient to provide an estimate for the thickness of the reflective layer. It should be noted that this constant varies strongly in the blue and ultraviolet part of the spectrum. Moreover, the constant is strongly dependent upon the pureness of the material, especially for metals like Au, Ag and Al wherein the pureness is important. Therefore, in each individual case, a measurement of the reflectivity should be undertaken on the basis of an actual surface.

When the above mentioned values are inserted into the formula, a thickness of 16,5 nm @ 589 nm is calculated.

For further details, reference is made to the book "Principles of Optics" written by Born and Wolf.

The first substrate and/or the second substrate and/or the third substrate and/or the fourth substrate may be a transparent substrate.

In an embodiment at least one substrate of the multi-layer structure may be a pealable foil adhesively bonded to the bearing substrate and/or a substrate of the multi-layer structure. All the layers of the multi-layer structure may be pealable foils. In an embodiment only a part to the layers of the multi-layer structure are pealable such as the three layers farthest off the bearing substrate, such as the two layers farthest off the bearing substrate, such as the layer farthest off the bearing substrate. In an embodiment every second layer in the multi-layer structure is a pealable foil, thus when a foil is pealed off two layers are removed from the optical storage medium, each of the two layers may comprise an information surface. In the latter embodiment it is possible to peal off two layers constituting a pair of DVD-layers.

The pealable foil may comprise a slip for removal of the foil from the substrate. Furthermore the pealable foil may in a pealed state be non-re-applicable to a surface of the optical storage medium. In the latter embodiment the foil may be used to detect if the optical storage medium has been used. Thus a non-transparent pealable layer may be applied to the surface of the multi-layer structure preventing recognition of the storage medium by an optical detecting means. When the foil is pealed off the storage medium may be read but as the foil is not re-applicable it is possible to see that the storage medium has been used.

In another embodiment the pealable foil comprises an information surface on which a first software is located. Underneath the pealable foil a second information surface may be positioned comprising a second software. The first software may be used to set up a computer so as to enable it to use the second software, thus when the first software has been loaded into the computer the pealable foil may be removed so as to make it possible to read the second software. This may be a way to ensure that a programme is only installed into ONE computer e.g. when information from the first and the second software

is needed to run an application. In an other embodiment the pealable foil may be a programme which needs to be loaded into a computer while the second information surface supports definition of a nano-structure e.g. it may be possible to write/record information on the second information surface.

Furthermore a supporting means may extend from a plan defined by the bearing substrate and/or the multi-layer structure. The supporting means may be used to ensure that a desired distance is provided from a laser adapted to read or write on the storage medium so that a desired focus of e.g. a laser beam is obtained. The supporting means may also be adapted to protect an information surface of the optical storage medium as it may elevate the information surface from a surface e.g. a table on which the optical storage medium is placed. Thus dirt or small particles will not damage the information surface.

The supporting means may be formed by a curled edge portion of the bearing substrate and/or the multi-layer structure substrate. The curled edge portion may be a portion which is bend so that it comprises a curved part and a part which has a cross-section which extends in substantially the same direction. The curl portion may also be shaped such that a cross-section may define at least a part of a helix.

The storage medium may be provided with a centre hole. The hole may be provided in the centre of the bearing substrate, but could also be provided in another part of the substrate different from the centre of gravity of the optical storage medium.

The curled edge-portion may be formed along an edge of the centre hole. Furthermore the curled edge-portion may be formed along an outer peripheral edge of the bearing substrate and/or the multi-layer structure. The optical storage medium may comprise a curl portion along both the centre hole and the outer peripheral edge. The curled edge portion of the centre hole and the curled edge portion of the outer peripheral edge may extend in substantially the same direction in relation to the plan defined by the bearing substrate and/or the multi-layer structure. But the curled edge portions may also extend in opposite directions. The curled edge portions may define an angle in relation to a plane defined by the bearing substrate and/or the multi-layer structure of 90 degrees, such as 80 degrees, such as 70 degrees, such as 60 degrees, such as 50 degrees, such as 45 degrees, such as 40 degrees, such as 30 degrees, such as 20 degrees, such as 10 degrees.

The optical storage medium may further comprise detachable protecting means for protecting at least a part of the nano-structure. The protecting means may cover a part of the information surface but could also protect the entire information surface. The protecting means may be adapted to engage the centre hole of the substrate. But the protecting means may also be adapted to engage the outer periphery of the optical storage medium. The means for engaging the optical storage medium may be means such as snap-locks which may make it possible to attach the protecting means to the optical storage medium again and again.

The peripheral surface of the protecting means may be shaped as a polygon, such as a quadrangle or a triangle, such as a polygon with five edges, such as a polygon with six edges, such as a polygon with seven edges, such as a polygon with eight edges, such as a polygon with nine edges, such as a polygon with ten edges. The protecting means may be shaped so as to enable positioning of the protecting means side by side with conventional CD-covers. Thus the protecting means may comprise an edge or a side adapted to contain information about the content of the optical storage medium e.g. the name of an artist or the name of a software application provided on an information surface of the substrate.

The bearing substrate may be made of a metal or an alloy, the metal or alloy comprising iron and/or steel and/or aluminium and/or magnesium and/or titanium and/or copper and/or nickel and/or zinc and/or cadmium and/or tin and/or lead and/or chrome and/or wolfram and/or silver and/or gold and/or platinum and/or stainless steel and/or tinplate and/or molybdenum. The bearing substrate may also be made of a non-transparent material comprising pieces of a metal so as to provide a stronger material.

In an embodiment the first substrate and/or second substrate and/or third substrate and/or the fourth substrate may comprise a non-metallic material. The non-metallic material may comprise an amount of a metallic material which may be magnetic. The non-metallic material may be semi-transparent, but could also be transparent. The non-metallic material may be selected from the group consisting of lacquers, polymers, elastomers, laminated plastic, printing inks or any combination thereof. The non-metallic material may also be made of a paper material such as card board. In an embodiment the medium may be made of cardboard in such a way that the medium may be comprised in e.g. a box made of card board. A weaking line may make it possible to press the medium out of the surface of the box. Thus the medium may be part of a package comprising e.g. cereals and a commercial for another product may be embedded in the surface of the box comprising the cereals.

The reflective layer may comprise a highly refractive material selected from the group consisting of aluminium, silver, gold, platinum, chrome, titanium dioxide and zirconium dioxide and any combination thereof. The reflective may also comprise alloys made from the aforementioned refractive materials. In an embodiment the bearing substrate is made of a material which may be polished so as to provide the reflective surface.

At least one of the reflective layers may comprise an active reflective layer which may be changed between a non-reflective position and a reflective position. The active reflective layer may be switched between a transparent state and a state where the screen is highly reflective, but the active reflective layer may also be switched to any semi-reflective position so as to reflect 90 % of an electromagnetic wave, such as 80 %, such as 70 % such as 60 %, such as 50 %, such as 40 %, such as 30 %, such as 20 %, such as 10 %.

The active reflective layer comprises liquid crystals adapted to be changed between the two positions. The liquid crystals may be those known from LCD-screens. An LCD screen or the properties and functionality of such a screen may be provided in the substrate. Thus the entire screen/layer may be reflective. In anther embodiment only a part of the screen is reflective e.g. while another is semi-reflective. The active layer may be adapted to show pictures e.g. black and white pictures in the layer/LCD-screen.

Thus the optical storage medium may comprise an active reflection layer and make it possible to access information in some layers in special situations. In an embodiment the optical storage medium may comprise a multi-layer structure comprising one or more layers having the properties of an LCD-screen. When a laser beam is directed to the medium a layer in e.g. the middle of the storage medium may not reflect the laser beam or may provide poor reflection of the laser beam if the LCD-screen like layer is not turned on. When the LCD-screen like layer is turned on a full or nearly full reflection may be provided and thus the information stored in the layer may be read.

The thickness of the bearing substrate may be selected within the range 100-1400 µm, such as within the range 125-1000 µm, such as within the range 150-800 µm, such as within the range 175-600 µm, such as within the range 200-400 µm, such as 225µm, such as 250 µm such as 275 µm, such as 300 µm, such as 325 µm, such as 350µm, such as 375µm.

The thickness of the first substrate may be selected within the range 0,1-1000 µm, such as within the range 0,5-750 µm, such as within the range 1-500 µm, such as within the range 1,5-250 µm, such as within the range 2-75 µm, such as within the range of 5-10 µm, such as within the range of 100-300 µm.

The thickness of the second substrate may be selected within the range 0,1-500 µm, such as within the range 2-450 µm, such as within the range 4-400 µm, such as within the range 6-350 µm, such as within the range 8-325 µm, such as within the range of 10-300µm.

The thickness of the third substrate may be selected within the range 0,1-500 µm, such as within the range 2-450 µm, such as within the range 4-400 µm, such as within the range 6-350 µm, such as within the range 8-325 µm, such as within the range of 10-300µm.

The thickness of the fourth substrate is selected within the range 0,1-500 µm, such as within the range 2-450 µm, such as within the range 4-400 µm, such as within the range 6-350 µm, such as within the range 8-325 µm, such as within the range of 10-300µm.

The total thickness of the optical storage medium including the bearing substrate and/or one or more layers and/or reflective layers may be selected within the range 100-1400 µm, such as within the range 125-1000 µm, such as within the range 150-800 µm, such as within the range 175-600 µm, such as within the range 200-400 µm, such as 225µm, such

as 250 µm such as 275 µm, such as 300 µm, such as 325 µm, such as 350µm, such as 375µm.

When designing the optical storage medium the thickness, the refractive index of the layers and the dimensions of the supporting means e.g. the curl portion may be designed such that the focus of the laser beam directed towards the optical storage medium may be acceptable so as to read the information on the optical storage medium

The thickness of the reflective layer may be selected within the range of 0,01-1µm, such as within the range of 0,02-0,09 µm, such as within the range of 0,03-0,08 µm, such as within the range of 0,04-0,07 µm, such as within the range of 0,05-0,06 µm, such as 0,05 µm. As the reflective layer may comprise an LCD-like layer the thickness may be selected within the range 100-1400 µm, such as within the range 125-1000 µm, such as within the range 150-800 µm, such as within the range 175-600 µm, such as within the range 200-400 µm, such as 225µm, such as 250 µm such as 275 µm, such as 300 µm, such as 325 µm, such as 350µm, such as 375µm.

The thickness of the curl portion may be within the range 100-1500 µm, such as within the range 300-1400 µm, such as within the range 500-1350 µm, such as within the range 750-1300 µm, such as within the range 1000-1250 µm, such as substantially 1200 µm. The thickness of the curl portion may be determined as de scribe in the best mode of carrying out the invention - see description of Fig. 8. The plane defined by the outer surface of the storage medium may be positioned in the opposite direction than the direction in which the curl portion extends. The curl portion may also be used to provide the desires focus of the laser beam.

In an embodiment the bearing substrate and/or the first substrate and/or the second substrate and/or the third and/or the fourth substrate may be provided with a colour print layer. The colour print layer may be provided on both sides of any substrate in the optical storage medium. The colour print may comprise a logo, a trademark, a picture, a stereogram, information about the content of the optical storage medium or any other kind of print. The colour print may be substantially transparent or may be semi-transparent such that a laser beam or any other electromagnetic wave may be able to pass through the colour print.

The colour print layer may be positioned between the bearing substrate and the first substrate. The colour print layer may be positioned between the first substrate and the second substrate. The colour print may be positioned between the second substrate and the third substrate. The colour print may be positioned between the third substrate and the fourth substrate. The colour print layer may be provided on a side of the fourth substrate opposite the third substrate. The colour prints of the different layer may be provided such that a picture or a desired visual effect is not obtained by the print on only one layer, but only by the colour prints of all or some of the layers. This may provide the effect that a first picture is visible when the pealable layer is provided on the optical

storage medium, but when the pealable layer is removed the picture is different or missing. The latter embodiment may make it possible so easy detect if the pealable layer has been removed.

At least one substrate in the multi-layer structure may be coloured, such as blue, green, reed or any other colour. The layers may comprise different colours such that when the pealable layer is attached to the optical storage medium one colour is seen (e.g. green), but when the pealable foil, which may be yellow, is removed a blue colour is seen.

In an embodiment the digital information represented in the nano-structure may be audio and/or video and/or data, such as data for a computer, such as data for a computer game application. The digital information may comprise a multi-channel sound such as 5.1 channels e.g. Dolby digital but the information may also comprise DTS sound and could comprise a combination of sound and picture such that a movie picture may be stored on the optical storage medium. The optical storage medium may comprise computer games e.g. combined with a movie picture. The information may be music or speech or noise or a recording of sound in nature or a recording of any other kind of sound.

The nanostructure may represent an image and/or text, such as a hologram. The hologram may be used to provide a sign of the authenticity of the optical storage medium and thus show that the medium is not a copy. The different layers of the optical storage medium may comprise one or more holograms, this may provide a special visual effect as a resulting hologram may be obtained.

The optical storage medium may be a Compact Disc, such as an audio CD, such as a super audio CD. The optical storage medium may be a CD-ROM, such as a read-only CD-ROM, such as a recordable CD-ROM, such as a re-writable CD-ROM. The optical storage medium may be a multi-layer medium, such as a DVD, such as a DVD+R/W such as a DVD-R/W such as a DVD-ROM. The optical storage medium may be e.g. a part of a disc-drive medium, such as a floppy disc such as a hard disc. Furthermore the optical storage medium may be a part of minidisc medium or a part of a can e.g. a lid or a side wall or a bottom part such that the medium may be defined in the can by a weakning line making it possible to press out and separate the optical storage medium. In another embodiment the storage medium may be glued or heat sealed on the can e.g. a side-wall, a bottom part or a top part of a can.

The optical storage medium may be adapted to be read by laser-source and/or an x-ray-source and/or an magnetic-resonance source. The optical storage medium may be used in a MR-scanner as a programme for the same or a means of updating the software in said MR-scanner. The optical storage medium may be provided such that the information surfaces may only be read by two lasers or three lasers or four lasers or five lasers.

According to a second aspect the invention relates to a method of making an optical storage medium comprising a bearing substrate, the bearing substrate comprising a substantially non-transparent material, said method comprising the steps of:

- forming an information surface into a surface of the optical storage medium, the information surface supporting definition of a first nano-structure representing information in digital form.

The step of forming the information surface may comprise forming a information surface readable to e.g. a CD-drive thus the information surface may comprise information such as sound, pictures etc. The step of forming the information surface may comprise the step of preparing the optical storage medium for recording or writing information into the information surface such as providing the geometrical structure described above. Thus the result of the process according to the first aspect of the invention may be a recorded or a recordable optical storage medium.

The method may further comprise the step of forming a first nano-structure into the information surface, the first nano-structure representing information in digital form.

The information surface may be provided on the bearing substrate. The step of forming the information surface into the bearing substrate may be followed by the step of polishing the surface so as to increase the reflective properties, but the polishing may also be done prior to forming the nano-structure into the bearing substrate so that the surface has the increased shining properties when the nano-structure is formed.

The method may further comprise the step of providing a first substrate on the bearing substrate. A nano-structure may be formed before and after providing the first substrate to the bearing substrate. When the nano-structure is formed into the bearing substrate after providing the first substrate said nano-structure may be formed into the bearing substrate by means of e.g. a laser.

The method according to the second aspect of the invention may comprise the step of forming an information surface into the first substrate. The information surface may be provided into the surface of the first substrate being provided to the bearing substrate but could also be provided to the surface facing away from the bearing substrate. The nano-structure of the first substrate may be provided prior to providing the first substrate to the bearing substrate. The method may comprise the step of joining the first substrate to the bearing substrate by means of gluing or welding or heat sealing.

The method according to the second aspect of the invention may comprise the step of providing a second substrate on the first substrate. A nano-structure may be provided in the same ways of for the first substrate.

The method may further comprise the step of forming an information surface into the second substrate. The information surface may be provided in the same way as it may be done on the first substrate.

According to the second aspect of the invention the method may further comprise the step of providing a third substrate on the second substrate. A nano-structure may be provided in the same ways of for the first substrate.

Furthermore a step of forming an information surface into the third substrate may be comprised in the method. The information surface may be provided in the same way as it may be done on the first substrate.

The method may comprise the step of providing a fourth substrate on the third substrate. A nano-structure may be provided in the same ways of for the first substrate. Further the method may comprise the step of forming an information surface into the fourth substrate. The information surface may be provided in the same way as it may be done on the first substrate.

The method may comprise the step of covering at least one information surface with a reflective material. The information surfaces may be covered with the reflective layer prior or after providing the substrate on which it is formed to another substrate.

Furthermore the method may comprise the step of forming a curled edge portion extending from a plan defined by the bearing substrate and/or the first substrate and/or the second substrate and/or the third substrate and/or the fourth substrate. The curled edge portion may be formed by means of a stamping process or a curling process and may be formed prior, in-between or after providing the layers of the optical storage medium.

According to the second aspect of the invention at least a part of the information surface may be formed or provide in the substrate or in a film layer by a rolling process, a stamping process, a thermal process, an etching process, a cutting process, an electroforming process, an electrolytic process, a magnetic moulding, moulding, extruding, an electro-chemical process, and/or a laser writing process, such as a direct laser writing process.
The moulding process may be an UV-moulding process or embossing in e.g. a not completely hardened mould (see e.g. WO 00/30854 which is hereby incorporated by reference) or an injection moulding process or any other moulding process. The thermal process may be a laser cutting process or a laser engraving process or any other thermal process. The pressing process may be a hydraulic press process or an excentre press process or any other pressing process.

The method may comprise any aspect (e.g. fig 7.5 and the pages explaining said figure) of

The Compact Disc Handbook (The Computer Music and Digital Audio Series, Vol 5), by Ken C. Pohlmann, Kenneth C. Pohlmann, ISBN: 0895793008

The method may comprise any aspect of (e.g. fig 5.2 and Fig. 5.3 and the pages describing said figure) of

DVD Demystified, by Jim Taylor, ISBN: 0071350268

The two books are hereby incorporated by reference.

The second aspect of the invention may comprise any feature or means of the first aspect as described in claims 1-75 and on the previous pages.

According to a third aspect the invention relates to use of a rolling process for forming an information surface into a substantially non-transparent material, said information surface supporting definition of at least a first nano-structure representing information in digital form.

The non-transparent material may be a metallic material. The information surface may comprise a first nano-structure representing information in digital form.

The third aspect of the invention may comprise any feature of the first and/or second aspect of the invention.

According to a fourth aspect the invention relates to the use of a stamping process for forming an information surface into a substantially non-transparent material, said information surface supporting definition of at least a first nano-structure representing information in digital form.

The non-transparent material may be a metallic material. The information surface may comprise a first nano-structure representing information in digital form.

The fourth aspect of the invention may comprise any feature of the first and/or second and/or third aspect of the invention.

According to a fifth aspect the invention relates to the use of a thermal process for forming an information surface into a substantially non-transparent material, said information surface supporting definition of at least a first nano-structure representing information in digital form.

The non-transparent material may be a metallic material. In an embodiment the non-transparent material may be transparent. The information surface may comprise a first nano-structure representing information in digital form.

The fifth aspect of the invention may comprise any feature of the first and/or second and/or third and/or fourth aspect of the invention.

According to a sixth aspect the invention relates to the use of an etching process for forming an information surface into a substantially non-transparent material, said information surface supporting definition of at least a first nano-structure representing information in digital form.

The non-transparent material may be a metallic material. In an embodiment the non-transparent material may be transparent. The information surface may comprise a first nano-structure representing information in digital form.

The sixth aspect of the invention may comprise any feature of the first and/or second and/or third and/or fourth and/or fifth aspect of the invention.

According to a seventh aspect the invention relates to the use of a cutting process for forming an information surface into a substantially non-transparent material, said information surface supporting definition of at least a first nano-structure representing information in digital form.

The non-transparent material may be a metallic material. In an embodiment the non-transparent material may be transparent. The information surface may comprise a first nano-structure representing information in digital form.

The seventh aspect of the invention may comprise any feature of the first and/or second and/or third and/or fourth and/or fifth and/or sixth aspect of the invention.

According to a eighth aspect the use of an electrolytic process for forming an information surface into a substantially non-transparent material, said information surface supporting definition of at least a first nano-structure representing information in digital form.

The non-transparent material may be a metallic material. In an embodiment the non-transparent material may be transparent. The information surface comprises a first nano-structure representing information in digital form.

The eighth aspect of the invention may comprise any feature of the first and/or second and/or third and/or fourth and/or fifth and/or sixth and/or seventh aspect of the invention.

According to a ninth aspect the use of a magnetic moulding process for forming an information surface into a substantially non-transparent material, said information surface supporting definition of at least a first nano-structure representing information in digital form.

The non-transparent material may be a metallic material. In an embodiment the non-transparent material may be transparent. The information surface comprises a first nano-structure representing information in digital form.

The ninth aspect of the invention may comprise any feature of the first and/or second and/or third and/or fourth and/or fifth and/or sixth and/or seventh and/or eighth aspect of the invention.

According to a tenth aspect the use of a moulding process for forming an information surface into a substantially non-transparent material, said information surface supporting definition of at least a first nano-structure representing information in digital form.

The non-transparent material may be a metallic material. The information surface comprises a first nano-structure representing information in digital form.

The tenth aspect of the invention may comprise any feature of the first and/or second and/or third and/or fourth and/or fifth and/or sixth and/or seventh and/or eighth and/or ninth aspect of the invention.

According to a eleventh aspect the use of an extruding process for forming an information surface into a substantially non-transparent material, said information surface supporting definition of at least a first nano-structure representing information in digital form.

The non-transparent material may be a metallic material. In an embodiment the non-transparent material may be transparent. The information surface comprises a first nano-structure representing information in digital form.

The eleventh aspect of the invention may comprise any feature of the first and/or second and/or third and/or fourth and/or fifth and/or sixth and/or seventh and/or eighth and/or ninth and/or tenth aspect of the invention.

According to a twelfth aspect the use of an electro-chemical process for forming an information surface into a substantially non-transparent material, said information surface supporting definition of at least a first nano-structure representing information in digital form.

The non-transparent material may be a metallic material. In an embodiment the non-transparent material may be transparent. The information surface comprises a first nano-structure representing information in digital form.

The twelfth aspect of the invention may comprise any feature of the first and/or second and/or third and/or fourth and/or fifth and/or sixth and/or seventh and/or eighth and/or ninth and/or tenth and/or eleventh aspect of the invention.

It is a further object of the present invention to provide an optical storage medium which may be read by a standard optical playback device, such as any Compact Disc player, Digital Versatile Disc player, any PC or Mac comprising an optical disk drive, such as a DVD or CD-ROM drive, any game platform, such as Playstation®, Xbox®, Nintendo GameCube, any MP3 player, any MPEG player, etc.

It is a further object of the present invention to provide an optical storage medium which may be recorded in a standard optical recording device.

It is a further object of the present invention to provide an optical storage medium which comprises compensating means, so that substantially no distortion of the playback signal is observed by the playback device.

In a further (13th) aspect of the invention the above and other objects are fulfilled by a an optical storage medium comprising:

- a substrate,
- an information surface being associated with the substrate and being located at a first optical path length from an outer surface of the storage medium, and
- at least one compensating layer positioned between the information surface and the outer surface changing the optical path from the outer surface to the information surface so as to adapt the storage medium to be read or recorded by a light source being pre-set to read or record information at an information surface located at a predetermined optical path length from an outer surface,

wherein the first optical path length is different form the predetermined optical path length.

In a still further (14th) aspect of the invention the above and other objects are fulfilled by an optical storage medium comprising:
- a substrate
- at least one information surface positioned at at least a first distance from an outer surface of the medium,
- a compensating layer positioned between the outer surface and the information surface for compensating for the at least first distance being different from a predetermined distance by optically altering a spot size of an incoming light beam on the information surface.

In another (15th) aspect of the invention the above and other objects are fulfilled by an optical storage medium comprising:
- a substrate
- at least one information surface positioned at at least a first distance from an outer surface of the medium,

wherein the information surface comprises information in the form of a deep surface relief, having a profile being larger than a predetermined profile whereby correction of aberrations caused by the at least first distance being different from a predetermined distance is obtained.

In a further (16th) aspect of the invention an optical medium is provided, the optical medium comprising:

- a substrate
- at least one information surface positioned at at least a first distance from an outer surface of the medium,
- a compensating layer positioned between the outer surface and the information surface for compensating for aberrations caused by the at least first distance being different form a predetermined distance.

Alternatively, the cone angle of an incoming light beam may be reduced, so that the optical storage medium comprises: a substrate, at least one information surface positioned at a first distance from an outer surface of the medium, and a compensating layer positioned between the outer surface and the information surface for compensating for the first distance being different from a predetermined distance by optically reducing a cone angle of an incoming/incident light beam.

In a standard CD or DVD, the distance between an outer surface of the CD or DVD and the information layer is set to be 1,2 mm or 0,6 mm of polycarbonate by the providers of the CD and DVD players. Thus, the optical system in the CD and DVD players is adjusted so as to read information on an information surface, comprising for example music or picture information through this specific layer. The optical system of the CD and DVD players is thus adjusted to suit the optical properties of a 1,2 or 0,6 mm thick layer of polycarbonate having optical grade quality or a polymer with similar optical properties, such as a polymer having low stress induced birefringence, such as Topas® manufactured by Hoechst.

However, in order to obtain a more reliable optical storage medium which do not deteriorate over time, e.g. upon exposure to UV light, it is an advantage to use less sensitive materials for optical storage.

In a preferred embodiment metals or alloys are used as a substrate, however also glass, polymers, such as elastomers, paper, cardboard, wood, fiber materials, bio-materials, stones, ceramics, concrete or any combinations thereof may be used as substrate.

The metal and/or alloys may be any metal or alloy, such as a metal or alloy comprising any materials selected from the group consisting of iron, steel, aluminium, magnesium, titanium, copper, nickel, zinc, cadmium, tin, lead, chrome, wolfram, silver, gold, platinum, stainless steel, tinplate and molybdenum.

The polymers to be used as substrate material may be any polymers, such as any thermoplastic, such as an amorphous thermoplastic or a crystalline thermoplastic, or any thermosetting plastics, such as any polymers having high stress induced birefringence, such as any polymers being optically anisotropic, and the substrate may alternatively or additionally comprise at least one material selected from the group consisting of polyester, polystyrene, PMMA, PS, PP, PE, PET, APET, ABS, HIBS, PC and acrylic.

However, when using a material other than polycarbonate, it is not always preferred to have a thickness of for example 1,2 mm, such as 1,2 mm +/- 0,1 mm, such as 1,2 mm + 0,3/-0,1.

So according to another aspect of the present invention the use of an information storage medium having a thickness of less than 1,1 mm in a standard optical playback device is provided.

According to the material properties of the substrate material, it may be preferred to have a thickness of less than 1,2 mm, such as of less than 1,1 mm, such as less than 1,09 mm, such as less than 1 mm, such as less than 0,8 mm, such as less than 0,6 mm, such as less than 0,4 mm, such as less than 0,2 mm.

The thickness of the substrate material may likewise be between 1,2 mm and 0,2 mm, such as between 1,1 mm and 0,15 mm, such as between 1,09 and 0,2 mm, such as between 1,0 mm and 0,3 mm, such as between 0,8 mm and 0,4 mm, such as between 0,7 and 0,5 mm, such as between 0,6 mm and 1,2 mm, such as between 600 μm and 1200 μm, or a thickness above 1,2 mm, such as a thickness above 1200 μm, such as a thickness above 1,3 mm, such as a thickness above 1,5 mm, such as a thickness between 1,55 mm and 3 mm.

The information surface may be formed in the substrate or it may be formed in a film layer deposited on the substrate. A buffer layer may be provided between the substrate and the film layer primarily for improving the adhesion of the film layer.

The buffer layer may for example be an acrylic or an epoxy having a good adhesion to e.g. a metal substrate and also to many materials to be used as film layer. For more porous materials, such as e.g. plastic, it may be sufficient to treat the surface to obtain a better adhesion of the film layer, for example by altering the free energy of the surface, such as by giving the surface a Corona treatment. Alternatively, the surface may be given a chemical surface treatment for improving adhesion to the surface.

The film layer may be reflective, or the film layer may be transparent at least in a specific wavelength range and the substrate or the buffer layer may be reflective. Alternatively, the film layer or the substrate may be covered by a reflective layer.

The film layer may be any polymer suitable for holding the information layer, i.e. any surface suitable for having a nano-structure embossed therein, the film layer may be any deposited film of metal, semi-conductor material, polymer, lacquer, etc.

It is preferred to coat the information surface formed either in the film layer or in the substrate by a protective layer so as to protect the information surface against dirt and small particles which could deteriorate the performance of the optical storage medium. Furthermore, the protective layer may serve as protection against corrosion. The protective layer may be coated on top of the reflective layer. Furthermore, the information surface formed either in the film layer or in the substrate may be coated by a planarising layer. The protective and planarising layer may be formed by the same layer, e.g. by one layer. By having a planarised surface of the storage medium, the storage medium is less sensitive to dirt and small particles present on the surface of the medium.

The information surface may be read or recorded through the substrate and/or through the compensating layer. In standard CD and DVD players the information surface is read through the substrate. However, when using a compensating layer, the need for reading through 1,2 or 0,6 mm of polycarbonate is eliminated and therefore, the structure of the storage medium may be provided to allow for reading either through the substrate and/or through the compensating layer. Depending on the structure, the read-through material may comprise either the substrate, the compensating layer or a combination.

In a standard system for reading or recording optical storage media, the optical system for reading or recording is carefully adapted to record or read optical information at an information surface positioned at a distance of 1.2 mm of polycarbonate or an other optical material having similar properties, such as a cyclicolifin copolymer, such as Topas® manufactured by Hoechst, from an outer surface of the media. When using a read-through material having another phase transfer function than the standard materials, or when using a media having a thickness different from a predetermined thickness, the phase of a propagating electromagnetic wave for reading or recording need to be adjusted or compensated so that they may still be read or recorded in a standard optical system.

In one preferred embodiment, the predetermined phase transfer function corresponds to the phase transfer function in a 1,2 mm thick polycarbonate material for a wave front having a wavelength of 785 nm propagating in the polycarbonate material of optical grade quality. In another preferred embodiment the predetermined phase transfer function corresponds to the phase transfer function for a wave front having a wavelength of 670 nm propagating in a 0.6 mm thick polycarbonate material of optical grade quality.

The substrate may comprise a number of materials each having different optical properties, and the phase transfer function is then calculated on the basis of the number of materials and their respective optical properties.

Furthermore, when using a read-through material having other optical properties than the standard polycarbonate material, the spot size of an incident light beam on the information surface will not correspond to the spot size of an incident light beam having propagated through the standard polycarbonate material, thus also the focus depth is changed.

To facilitate reading of the information surface by a standard optical reading/recording system when the phase transfer function and/or the spot size on the information surface is changed, a compensating layer need to be inserted to compensate for the change in phase transfer function and/or spot size.

The compensating layer may compensate for the information layer being positioned at at least a first distance from an outer surface of the storage medium, the at least first distance being different from a predetermined distance.

The compensation may be provided for example by providing an interference filter, such as a bandwidth filter, in the path of the propagating electromagnetic wave to read or record the information of the information surface.

The interference filter(s) may comprise transmission or reflection filters, or a combination of reflection and transmission filters. Furthermore, the interference filters may comprise low pass or high pass filters, or a combination of high pass, low pass, reflection and transmission filters. Hereby, for example filters allowing for passing of more than one specific wavelength may be designed, e.g. to allow for reading or recording of multiple information surfaces by multiple wavelengths.

Preferably, the transmission/reflection characteristic of the filters is selected to be within +/- 20 nm of a centre wavelength, such as within +/- 15 nm, such as within +/- 10 nm, even more preferred within +/- 5 nm. Furthermore, asymmetric filters may be preferred, in that asymmetric filters tends to be less sensitive to a phase change of the incident light. Thus, a filter having a few nm asymmetry, such as 2, 3, 4, or 5 nm of asymmetry may be used.

Furthermore, when using high pass and/or low pass filters, they may be selected to have a transmission/reflection characteristic having an edge slope of less than 20 nm, such as less than 15 nm, such as less than 10 nm, preferably such as less than 5 nm.

The compensating layer may comprise at least one dielectric layer. For example such as a dielectric layer may comprise multiple layers, for example so that each of the alternating layers has an index of refraction being significant of said layer and preferably so that the alternating layers have high and low refractive indices, respectively. The dielectric multi-layered interference filters may be formed so that the high refractive index material layers and the low refractive index layers are alternately layered with a thickness of 1/4 of a predetermined wavelength, λ, preferably being the wavelength of the light for reading the information surface. Preferably, the indices of refraction of the alternating layers are

chosen within a range from approximately 1.2 to approximately 2.5. The dielectric layer may for example comprise at least a first layer having a relatively low index of refraction being within a range from approximately 1.2 to approximately 1.6, and at least a second layer having a relatively high index of refraction being within a range from approximately 2.0 to approximately 2.5. It is, though, envisaged that the optimum thicknesses and/or indices of refraction are dependent on the specific light source to be used for reading and/or recording and of the wavelength of the light emitted from the light source. Furthermore, the thickness of the layers may be tightly controlled according to the wavelength of the light to be incident on the specific dielectric layer, and it is further preferred to manufacture the dielectric layer so that the water content of the dielectric layer is minimized.

It is, thus, to be understood that the dielectric layers are manufactured so as to provide a match between the dielectric layer and the emitted wavelength of the specific light source to be used in a specific system.

The number of layers in such a dielectric layer may depend on the manufacturing process and may be for example more than 20, such as more than 40, such as more than 60, such as more than 80, such as more than 100 layers, such as more than 300 layers, such as more than 500 layers. For example between 20 and 100 layer, between 100 and 300 layers, between 20 and 500 layer, such as between 100 and 400 layers.

The high refractive index material is preferably PbO_2, ZrO_2, TiO_2, ZnS, etc, and the low refractive index material is preferably SiO_2, MgF_2, Al_2O_3, Na_3AlF_6 (cryolite), etc. It should, however, be envisaged that also other dielectric materials may be used to obtain a layer having the desired properties.

By shifting the thickness of each layer and/or by combining several reflective layers having different wavelength bandwidths, the wavelength of the reflected/transmitted light may be carefully selected. An intermediate layer, preferably having a thickness corresponding to the predetermined wavelength may be provided between alternating layers of high refractive index material and low refractive index material so as to provide a dielectric stack.

In a preferred embodiment the multi-layered structure comprises alternating layers of titanium-dioxide (TiO_2) and quartz (SiO_2 or SiO_x), each having a thickness corresponding to 1/4 of a predetermined wavelength (= L). The number of alternating layers of TiO_2 and SiO_x, may be interconnected via an intermediate layer, such as a SiO layer to form a dielectric stack. Preferably, the thickness of the intermediate layer corresponds to the predetermined wavelength (= 4L).

The layers may be evaporated on to the surface by evaporation, such as by electron beam evaporation, by sputtering or preferably by deposition, such as by chemical vapour deposition, such as by low pressure chemical vapour deposition. Alternatively, a film layer

may be a separate film or foil adapted to be laminated, glued, bonded or adhered to the substrate or any buffer layer on the substrate by any other means.

Alternatively, the multi layer films may comprise polymers, such as alternating layers of different polymers. Preferably, the alternating polymer layers are manufactured by extruding the polymer materials under heat and pressure and combined into a multi layer web with controlled layer thickness distribution. This web of thick material is then stretched to form a final multi layer film having the desired optical properties.
In a preferred embodiment the compensating layer comprises optical birefringent material. Hereby, for example the reflectivity of the compensating layer for p-polarized light may be controlled by controlling the birefringent properties of the birefringent material. For example, the Brewsters angle of the compensating layer may be controlled by controlling the birefringent properties of the birefringent material.

The polymers may comprise alternating layers of polyesters and acrylics, such as polyethylene naphathalate (PEN) and polymethylmethacrylate (PMMA). Acrylics are usually optically isotropic and have a refractive index of about 1.48. Polyesters can range from being optically isotropic to being highly anisotropic and may have a refractive index from 1,5 to 1,75.

The compensating layer may further comprise liquid crystal materials to provide an interference filter, for example comprising Chiral Nematic crystals.
The information surface may be provided in the compensating layer, hereby having the compensating layer corresponding to the film layer mentioned above.

Furthermore, to reduce the number of steps required for manufacturing of an optical storage medium the film layer may comprise an interference filter. Furthermore, the information surface may be formed in the interference filter.

It may be an advantage that the interference filters described herein typically are polarisation dependent.

The thickness of the compensating layer may be 0,5 μm - 200 μm, such as 0,5μm - 150μm, 1μm - 100μm, preferably such as 1μm - 50μm, 5μm -40μm, 8μm - 35μm, 10μm - 30μm, 15μm -25μm, 20μm - 25μm.

Alternatively or additionally, optical aberrations, such as chromatic aberrations, spherical aberrations, and/or off-axis aberrations or other phase aberrations may be corrected for by providing a deep surface relief as the information surface. To obtain a correction for the aberrations, the surface profile i.e. grooves, tracks, pits and/or indentations need to be deeper/higher than in a standard optical storage medium, so that the deep surface relief may act as an artificial dielectric surface. For example, the pit depth may be more than 0,5 μm, such as between 0,5 μm - 10 μm, such as between 1 μm - 5 μm, or the height may be more than 1 μm. However, it is preferred that the pit depth satisfies the condition for

obtaining constructive or destructive interference on a detector for proper detection of data, the condition for obtaining constructive or destructive interference being wavelength dependent.

The information surface is a surface from which information may be obtained by reading the surface by an optical light source. The information surface may comprise a first nano -structure representing information in digital form.

The thirteenth aspect of the invention may comprise any feature of the first, second and/or third, fourth, fifth, sixth, seventh, eighth, ninth, tenth, eleventh and/or twelfth aspect of the invention.

The fourteenth aspect of the invention may comprise any feature of the first, second, third, fourth, fifth, sixth, seventh, eighth, ninth, tenth, eleventh, twelfth and/or thirteenth aspect of the invention.

The fifteenth aspect of the invention may comprise any feature of the first, second, third, fourth, fifth, sixth, seventh, eighth, ninth, tenth, eleventh, twelfth, thirteenth and/or fourteenth aspect of the invention.

The sixteenth aspect of the invention may comprise any feature of the first, second, third, fourth, fifth, sixth, seventh, eighth, ninth, tenth, eleventh, twelfth, thirteenth, fourteenth and/or fifteenth aspect of the invention.

Thus, all the embodiments and aspects described in the present application may be combined in any way.

Detailed description of the invention

An embodiment of the invention will now be described in details with reference to the drawing in which:

Figs. 1-6 shows different embodiments of the invention according to the first aspect,

Fig. 7 shows a principle structure of the invention according to the first aspect,

Figs. 8a-8d shows different embodiments of the curl portion according to the first aspect,

Figs. 9a-9b shows different embodiments of stiffness providing means,

Fig. 10 shows a cover according to the first aspect of the invention,

Fig. 11 shows a substrate comprising a plurality of information surfaces, and

Fig. 12 shows an embodiment of an optical storage medium, wherein a reflective layer follows the nano-structure.

Fig. 13 shows an embodiment of an optical storage medium comprising a compensating layer.

Fig. 14 shows an embodiment of an optical storage medium comprising a combined compensating and reflecting layer.

Fig. 1 shows an optical storage medium 2 comprising a bearing substrate 4 comprising an information surface 6 on which a nano-structure 8 is provided on a first side 10 of the bearing substrate 4. The bearing substrate is made of a non-transparent material, such as aluminium or steel or a non-transparent plastic material. A protecting layer 12 is provided on the nano-structure 8. In an embodiment the nano-structure 8 is provided to the protecting layer 12 prior to attaching the protecting layer 12 to the bearing substrate 4. A nano-structure may also be provided on a second side 14 of the bearing substrate (not shown). The second side 14 of the bearing substrate 4 and the outer surface 16 of the protecting layer 12 are parallel. On the bearing substrate 4 may be provided a plurality of information surfaces 6, such as one, such as two, such as three, such as four or any other number or information surfaces. The information surfaces 8 may be arranged in zones e.g. in four half-circles each comprising an information surface 8. The information surfaces may also have any other shape such as concentric circles or helixes.

Fig. 2 shows an optical storage medium 2 according to first aspect of the invention. The optical storage medium 2 comprises a bearing substrate 4 comprising a first layer 16 and a second layer 18 which is provided on two sides of the first layer 16. The first layer 16 is made of steel and the second layer 18 is made of tin. The first layer 16 and the second layer 18 may also comprise any other kind of non-transparent material. Thus the second layer 18 may serve as protection against corrosion of the first layer 16. On one of the second layers 18 is provided an information surface 6 comprising a nano-structure 8. A protecting layer 12 is provided on top of the nano-structure 8 and thus the nano-structure 8 is also provided in the protecting layer 12. The advantage of the second layer 18 of the bearing substrate may also be to provide a material in which it is easier to emboss the nano-structure 8, while the first layer 16 provides the desired stiffness of the bearing substrate 4. As described under Fig. the bearing substrate 4 may be provided with a plurality of information surfaces 6.

Fig. 3 shows an optical storage medium 2 comprising a bearing substrate 4. The bearing substrate 4 is made of a non-transparent material such as a metal. On a first side 10 of the bearing substrate 4 is provided a multi-layer structure 20 comprising a layer 22 comprising an information surface 6 comprising a nano-structure 8. The layer 22 may be a first substrate but could also be a second, third or fourth substrate according to the first aspect of the invention. On the nano-structure 8 is provided a reflective layer 24 enhancing reflection from the nano-structure when an electromagnetic wave e.g. a laser

beam is directed towards a upper surface 26 of the layer 22 and transmitted through the layer 22 and reflected by the reflective layer 24. The reflecting layer 24 then reflects the electromagnetic wave and the nano-structure 8 may be detected by a means for detecting electromagnetic waves. The multi-layer structure 20 is laminated or glued to the bearing substrate 4, by means of a laminating layer 28. The bearing substrate 4 may comprise a number of information surfaces 6.

In Fig. 4 is shown a bearing substrate 4, which is non-transparent e.g. made of a metal. The bearing substrate 4 may comprise a single layer but could also comprise a plurality of layers as described above. The bearing substrate 4 is provided with a structure supporting layer 30 which may be a lacquer and may be a first, second, third or fourth layer of the invention according to the first aspect of the invention. On the structure supporting layer 30 is provided an information surface 6 comprising a nano-structure 8. On the nano-structure 8 is provided a reflective layer 24. In some applications the reflective layer 24 will be provided as shown in Fig. 4 while in others the reflective layer 24 will follow the surface of the nano-structure 8 more smoothly as the thickness of the reflective layer 24 will be substantially equal all over the nano-structure 8 as shown in Fig. 12. On the reflecting layer 24 is provided a protecting layer 12. The protective layer may be a lacquer or a polymer film and could be a first, second, third or fourth layer of the invention according to the first aspect of the invention. In fig 4. the protecting layer 12 is transparent.

As described in the preceding some embodiments of the invention according to the first aspect of the invention may comprise a plurality of information surfaces 6a and 6b. An example of this is shown in Fig. 5 wherein the optical storage medium 2 comprises two information surfaces 6a and 6b. The optical storage medium 2 comprises a bearing substrate 4. On the bearing substrate is provided a structure supporting layer 30, comprising a first information surface 6b, which is covered by a reflective layer 24. The first information surface 6b comprises a first nano-structure 8b. On the reflective layer 24 may be provided a second structure supporting layer 31 comprising a second information surface 6a. The second information surface 6a comprises a second nano-structure 8a on which may be provided a semi-reflective layer 32. The second structure supporting layer 31 may be semi-transparent. On the semi-reflective layer 32 is provided a protecting layer 12.

In Fig. 6 is provided a bearing substrate 4 on which is provided a structure supporting layer 30. On the structure supporting layer 30 is provided a first information surface 6b comprising a first nano-structure 8b. The first information surface 6b is covered by a reflective layer 24. On the reflective layer is provided a second structure supporting layer 31 comprising the second information surface 6a which comprises a second nano-structure 8a. The second structure supporting layer 31 may be semi-transparent. The second information surface 6a is covered by a protecting layer 12.

Fig 7. shows a multi-layer structure according to the first aspect of the invention. The multi-layer structure comprises a first substrate 34, a second substrate 36 and a third substrate 38. The first substrate 34 comprises a first surface 40 and a second surface 42. The second substrate 36 comprises a first surface 44 and a second surface 46. The third substrate 38 comprises a first surface 48 and a second surface 50. Any of the first surfaces 40, 44, 48 and any of the second surfaces 42, 46, 50 may comprise one or more information surfaces which may comprise one or more nano-structures. As an example one of the surfaces may comprise four information surfaces grouped in four zones dividing the surface into four half circles. Any other number of information surfaces may be provided on a surface. On any information surface may be provided a reflective layer or the substrate may be made of a reflective layer which may be reflective with or without being polished.

Figs. 8a-8d, 9a-9b and 10 shows different embodiments of curl portions 52 of the optical storage medium 2 having a centre axis 54 and an information surface 6. The thickness 56 of the curl portion 52 is determined as shown in the figure. Figs. 9a and 9b further shows stiffness supporting means 58. Fig. 10 further shows a cover 60 comprising a surface 62 on which information about the content of the optical storage medium 2 is provided. The cover 60 may be quadrangular.

Fig. 11 shows a optical storage medium 2 having a centre axis 54 and comprising a plurality of information surfaces i.e. a first information surface 64, a second information surface 66, a third information surface 68 and a fourth information surface 70. Any other number of information surfaces may be provided on a surface of the optical storage medium and the information surfaces may have any shape.

In Fig. 12, the nano-structure of an information surface 6 is covered with a reflective layer 24. The reflective layer is covered with a layer of protective lacquer 121 or with similar means for protecting the surface of the reflective layer. The reflective layer is provided so that both surfaces thereof, i.e. the surface facing the information surface and the surface facing the protective lacquer narrowly follows the contour of the information surface. Accordingly, the two surfaces of a reflective material both forms contours representing the same information.

Fig. 13 shows a cross-section of one embodiment of an optical storage medium according to the invention. On a substrate 131, a buffer or adhesion layer 132 is provided for obtaining a good connection between substrate 131 and film layer 133. The information structure is embossed in the film layer 133 to form an information surface, such as for example a nano-structure embossed in the film layer 133 to represent information in digital form. The information surface is coated by a reflective layer 134, such as a metallic layer, preferably such as an aluminium layer. The reflective layer 134 is preferably evaporated on to the information surface, and as shown in Fig. 13, the reflective layer 134 is sufficiently thin so as to allow for a conform coverage of the information surface. A

planarising layer 135 is provided on top of the reflective layer for planarising of the surface.

On the planarising layer, a compensating layer 136 is provided for compensating for any aberrations not otherwise corrected for in the system, such as aberrations inferred by the provision of an optical storage medium having a thickness other than the thickness expected by the optical system, or comprises a material having different optical properties than the optical material properties expected by the optical system.

The whole structure is covered by a protective layer 137 protecting the surface of the structure.

Fig. 14 shows a cross-section of another embodiment of an optical storage medium according to the invention. On a substrate 131, a buffer or adhesion layer is provided for obtaining a good connection between substrate 131 and film layer 140. The buffer or adhesion layer is an optional layer, which may be omitted provided that a good connection can be provided either directly between the substrate and the film layer or by giving the substrate a surface treatment, such as a Corona treatment or a chemical surface treatment.

The information surface is provided to the film layer 140. The film layer 140 is a reflective layer so that no additional reflective layer is needed. Furthermore, the film layer 140 comprises the compensating layer 136, for example in the form of an interference filter, for compensating for any aberrations in the system caused for example by the optical storage medium having a thickness different from a predetermined thickness determined by the optical system, or comprises a material having a different phase transfer function than the phase transfer function determined by the optical system.

A planarising layer is provided on the film layer 140 comprising the nano-structure, the reflective layer and the compensating layer. Finally, a protective layer is provided on top of the planarising layer. It is envisaged that in an alternative embodiment the planarising layer may also form the protective layer.

CLAIMS

1. An optical storage medium comprising at least one information surface supporting definition of at least a first nano-structure representing information in digital form, the optical storage medium further comprising a substrate comprising a substantially non-transparent material.

2. An optical storage medium according to claim 1, wherein the information surface comprises a first nano-structure representing information in digital form.

3. An optical storage medium according to claim 1 or 2, wherein the information surface makes the optical storage medium recognisable for an optical detecting device.

4. An optical storage medium according to any of claims 1-3, wherein the bearing substrate comprises at least one metallic material.

5. An optical storage medium according to any of claims 1-4, wherein the bearing substrate is a non-metallic material selected from the group consisting of glass, polymers, elastomers, paper, cardboard, wood or any combination thereof.

6. An optical storage medium according to any of the preceding claims, further comprising a second nano-structure supporting definition of the first nano-structure.

7. An optical storage medium according to any of claims 1-6, wherein the information surface comprises at least one geometrical structure supporting definition of the first nano-structure.

8. An optical storage medium according to claim 7, wherein the geometrical structure comprises a first zone defining a first nano-structure and/or a second zone defining the second nanostructure.

9. An optical storage medium according to claims 7 or 8, wherein the geometrical structure forms a helix.

10. An optical storage medium according to any of claims 7-9, wherein the optical storage medium comprises a plurality of concentric geometrical structures.

11. An optical storage medium according to any of the preceding claims, wherein the bearing substrate comprises a first and an opposite second surface, at least one of said surfaces comprising at least one information surface.

12. An optical storage medium according to any of the preceding claims, further comprising a first substrate having a first and a second surface, the first substrate being substantially parallel to a plane defined by the bearing substrate.

13. An optical storage medium according to claim 12, wherein at least one of the first and the second surfaces of the first substrate comprises at least one information surface.

14. An optical storage medium according to any of the preceding claims, further comprising a second substrate having a first and a second surface, the second substrate being substantially parallel to a plane defined by the bearing substrate.

15. An optical storage medium according to claim 14, wherein at least one of the first and the second surfaces of the second substrate comprises at least one information surface.

16. An optical storage medium according to any of the preceding claims, further comprising a third substrate having a first and a second surface, the third substrate being substantially parallel to a plane defined by the bearing substrate.

17. An optical storage medium according to claim 16, wherein at least one of the first and the second surfaces of the third substrate comprises at least one information surface.

18. An optical storage medium according to any of the preceding claims, further comprising a fourth substrate having a first and a second surface, the fourth substrate being substantially parallel to a plane defined by the bearing substrate.

19. An optical storage medium according to claim 18, wherein at least one of the first and the second surfaces of the fourth substrate comprises at least one information surface.

20. An optical storage medium according to any of the preceding claims, wherein at least a part of at least one information surface is covered with a reflective layer.

21. An optical storage medium according to claim 20, wherein the reflective layer comprises a metallic material.

22. An optical storage medium according to of claims 12-21, wherein at least one information surface of the bearing substrate is reflective.

23. An optical storage medium according to any of claims 12-22, further comprising a multi-layer structure provided on the first surface of the bearing substrate.

24. An optical storage medium according to any of claims 12-23, further comprising a multi-layer structure provided on the second surface of the bearing substrate.

25. An optical storage medium according to claim 23 or 24, wherein the multi-layer structure comprises the first substrate and/or the second substrate and/or the third substrate and/or the fourth substrate.

26. An optical storage medium according to any of claims 23-25, wherein the multi-layer structure comprises the first substrate, at least a part of said first substrate being connected to the surface on the bearing substrate on which the multi-layer structure is provided.

27. An optical storage medium according to any of claims 23-26, wherein the multi-layer structure further comprises the second substrate, at least a part of said second substrate being connected to a surface of the first substrate.

28. An optical storage medium according to any of claims 23-27, wherein the multi-layer structure further comprises the third substrate, at least a part of said third substrate being connected to a surface of the second substrate.

29. An optical storage medium according to any of claims 23-28, wherein the multi-layer structure further comprises the fourth substrate, at least a part of said fourth substrate being connected to a surface of the third substrate.

30. An optical storage medium according to any of claims 14-29, wherein the propagation rate of an electromagnetic wave in the first substrate is lower than the propagation rate of the electromagnetic wave in the second substrate.

31. An optical storage medium according to any of claims 14-30, wherein the coefficient of reflection of the first substrate is higher than the coefficient of reflection of the second substrate, such as 10 percentage points higher, such as 20 percentage points higher, such as 30 percentage points higher, such as 40 percentage points higher, such as 50 percentage points higher, such as 60 percentage points higher, such as 70 percentage points higher, such as 80 percentage points higher, such as 90 percentage points higher.

32. An optical storage medium according to any of claims 16-31, wherein the propagation rate of an electromagnetic wave in the second substrate is lower than the propagation rate of the electromagnetic wave in the third substrate.

33. An optical storage medium according to any of claims 16-32, wherein the coefficient of reflection of the second substrate is higher than the coefficient of reflection of the third substrate, such as 10 percentage points higher, such as 20 percentage points higher, such as 30 percentage points higher, such as 40 percentage points higher, such as 50 percentage points higher, such as 60 percentage points higher, such as 70 percentage points higher, such as 80 percentage points higher, such as 90 percentage points higher.

34. An optical storage medium according to any of claims 18-33, wherein the propagation rate of an electromagnetic wave in the third substrate is lower than the propagation rate of the electromagnetic wave in the third substrate.

35. An optical storage medium according to any of claims 18-34, wherein the coefficient of reflection of the third substrate is higher than the coefficient of reflection of the fourth substrate, such as 10 percentage points higher, such as 20 percentage points higher, such as 30 percentage points higher, such as 40 percentage points higher, such as 50 percentage points higher, such as 60 percentage points higher, such as 70 percentage points higher, such as 80 percentage points higher, such as 90 percentage points higher.

36. An optical storage medium according to any of claims 18-35, wherein the first substrate and/or second substrate and/or the third substrate and/or the forth substrate is a semi-transparent material.

37. An optical storage medium according to any of claims 18-36, wherein the first substrate and/or the second substrate and/or the third substrate and/or the fourth substrate is a transparent substrate.

38. An optical storage medium according to any of claims 18-37, wherein at least one substrate of the multi-layer structure is a pealable foil adhesively bonded to the bearing substrate and/or a substrate of the multi-layer structure.

39. An optical storage medium according to claim 38, wherein the pealable foil comprises a slip for removal of the foil from the substrate.

40. An optical storage medium according to claim 38 or 39, wherein the pealable foil in a pealed state is non-re-applicable to a surface of the optical storage medium.

41. An optical storage medium according to any of the preceding claims, further comprising a supporting means extending from a plan defined by the bearing substrate and/or the multi-layer structure.

42. An optical storage medium according to claim 41, wherein the supporting means is formed by a curled edge portion of the bearing substrate and/or the multi-layer structure substrate.

43. An optical storage medium according to any of the preceding claims, wherein the storage medium is provided with a centre hole.

44. An optical storage medium according to claim 43, wherein the curled edge-portion is formed along an edge of the centre hole.

45. An optical storage medium according to any of claims 42-44, wherein the curled edge-portion is formed along an outer peripheral edge of the bearing substrate and/or the multi-layer structure.

46. An optical storage medium according to claim 45, wherein the curled edge portion of the centre hole and the curled edge portion of the outer peripheral edge extends in substantially the same direction in relation to the plan defined by the bearing substrate and/or the multi-layer structure.

47. An optical storage medium according to any of the preceding claims, further comprising detachable protecting means for protecting at least a part of the nano-structure.

48. An optical storage medium according to claim 49, wherein the protecting means is adapted to engage the centre hole of the substrate.

49. An optical storage medium according to claims 47 or 48, wherein the peripheral surface of the protecting means is shaped as a polygon, such as a quadrangle or a triangle.

50. An optical storage medium according to any of the preceding claims, wherein the bearing substrate is made of a metal or an alloy, the metal or alloy comprising iron and/or steel and/or aluminium and/or magnesium and/or titanium and/or copper and/or nickel and/or zinc and/or cadmium and/or tin and/or lead and/or chrome and/or wolfram and/or silver and/or gold and/or platinum and/or stainless steel and/or tinplate and/or molybdenum.

51. An optical storage medium according to any of claims 18-50, wherein the first substrate and/or second substrate and/or third substrate and/or the fourth substrate comprises a non-metallic material.

52. An optical storage medium according to claim 51, wherein the non-metallic material is selected from the group consisting of lacquers, polymers, elastomers, laminated plastic, printing inks or any combination thereof.

53. An optical storage medium according to any of claims 18-52, wherein the reflective layer comprises a highly refractive material selected from the group consisting of aluminium, silver, gold, platinum, chrome, titanium dioxide and zirconium dioxide and any combination thereof.

54. An optical storage medium according to any of the preceding claims, wherein the thickness of the bearing substrate is selected within the range 100-1400 µm, such as within the range 125-1000 µm, such as within the range 150-800 µm, such as within the

range 175-600 µm, such as within the range 200-400 µm, such as 225µm, such as 250 µm such as 275 µm, such as 300 µm, such as 325 µm, such as 350µm, such as 375µm.

55. An optical storage medium according to any of claims 12-54, wherein the thickness of the first substrate is selected within the range 0,1-1000 µm, such as within the range 0,5-750 µm, such as within the range 1-500 µm, such as within the range 1,5-250 µm, such as within the range 2-75 µm, such as within the range of 5-10 µm, such as within the range of 100-300 µm.

56. An optical storage medium according to any of claims 14-55, wherein the thickness of the second substrate is selected within the range 0,1-500 µm, such as within the range 2-450 µm, such as within the range 4-400 µm, such as within the range 6-350 µm, such as within the range 8-325 µm, such as within the range of 10-300µm.

57. An optical storage medium according to any of claims 16-56, wherein the thickness of the third substrate is selected within the range 0,1-500 µm, such as within the range 2-450 µm, such as within the range 4-400 µm, such as within the range 6-350 µm, such as within the range 8-325 µm, such as within the range of 10-300µm.

58. An optical storage medium according to any of claims 18-57, wherein the thickness of the fourth substrate is selected within the range 0,1-500 µm, such as within the range 2-450 µm, such as within the range 4-400 µm, such as within the range 6-350 µm, such as within the range 8-325 µm, such as within the range of 10-300µm.

59. An optical storage medium according to any of claims 21-58, wherein the thickness of the reflective layer is selected within the range of 0,01-1µm, such as within the range of 0,02-0,09 µm, such as within the range of 0,03-0,08 µm, such as within the range of 0,04-0,07 µm, such as within the range of 0,05-0,06 µm, such as 0,05 µm.

60. An optical storage medium according to any of claims 21-59, wherein at least one of the reflective layers comprises an active reflective layer which may be changed between a non-reflective position and a reflective position.

61. An optical storage medium according to claim 60, wherein the active reflective layer comprises liquid crystals adapted to be changed between the two positions.

62. An optical storage medium according to any of the preceding claims, wherein the thickness of the curl portion is within the range 100-1500 µm, such as within the range 300-1400 µm, such as within the range 500-1350 µm, such as within the range 750-1300 µm, such as within the range 1000-1250 µm, such as substantially 1200 µm.

63. An optical storage medium according to any of the preceding claims, wherein the bearing substrate and/or the first substrate and/or the second substrate and/or the third and/or the fourth substrate is provided with a colour print layer.

64. An optical storage medium according to claim 63, wherein the colour print layer is positioned between the bearing substrate and the first substrate.

65. An optical storage medium according to claims 63 or 64, wherein the colour print layer is positioned between the first substrate and the second substrate.

66. An optical storage medium according to any of claims 63-65, wherein the colour print layer is positioned between the second substrate and the third substrate.

67. An optical storage medium according to any of claims 63-66, wherein the colour print layer is positioned between the third substrate and the fourth substrate.

68. An optical storage medium according to any of claims 63-67, wherein the colour print layer is provided on a side of the fourth substrate opposite the third substrate.

69. An optical storage medium according to any of claims 18-68, wherein at least one substrate in the multi-layer structure is coloured.

70. An optical storage medium according to any of the preceding claims, wherein the digital information represented in the nano-structure is audio and/or video and/or data, such as data for a computer, such as data for a computer game application.

71. An optical storage medium according to any of the preceding claims, wherein the nanostructure represents an image and/or text, such as a hologram.

72. An optical storage medium according to any of the preceding claims, wherein the optical storage medium is a Compact Disc, such as an audio CD, such as a super audio CD.

73. An optical storage medium according to any of the preceding claims, wherein the optical storage medium is a CD-ROM, such as a read-only CD-ROM, such as a recordable CD-ROM, such as a re-writable CD-ROM.

74. An optical storage medium according to any of the preceding claims, wherein the optical storage medium is a multi-layer medium, such as a DVD, such as a DVD+R/W such as a DVD-R/W such as a DVD-ROM.

75. An optical storage medium according to any of the preceding claims, wherein the optical storage medium is a disc-drive medium, such as a floppy disc such as a hard disc.

76. An optical storage medium according to any of the preceding claims, wherein the optical storage medium is adapted to be read by laser-source and/or an x-ray-source and/or an magnetic-resonance source.

78. A method of making an optical storage medium comprising a bearing substrate, the bearing substrate comprising a substantially non-transparent material, said method comprising the steps of:

- forming an information surface into a surface of the optical storage medium, the information surface supporting definition of a first nano-structure representing information in digital form.

79. A method according to claim 78, further comprising the step of forming a first nano-structure into the information surface, the first nano-structure representing information in digital form.

80. A method according to claim 78 or 79, wherein the information surface is provided on the bearing substrate.

81. A method according to claims 78-80, further comprising the step of providing a first substrate on the bearing substrate.

82. A method according to any of claims 78-81, further comprising the step of forming an information surface into the first substrate

83. A method according to claims 78-82, further comprising the step of providing a second substrate on the first substrate.

84. A method according to any of claims 78-83, further comprising the step of forming an information surface into the second substrate.

85. A method according to claims 78-84, further comprising the step of providing a third substrate on the second substrate.

86. A method according to any of claims 78-85, further comprising the step of forming an information surface into the third substrate.

87. A method according to claims 78-86, further comprising the step of providing a fourth substrate on the third substrate.

88. A method according to any of claims 78-87, further comprising the step of forming an information surface into the fourth substrate.

89. A method according to any of claims 78-88, further comprising the step of covering at least one information surface with a reflective material.

90. A method according to any of claims 78-89, further comprising the step of forming a curled edge portion extending from a plan defined by the bearing substrate and/or the first

substrate and/or the second substrate and/or the third substrate and/or the fourth substrate.

91. A method according to any of claims 78-90, wherein at least a part of the information surface is formed by a rolling process and/or a stamping process and/or a thermal process and/or an etching process and/or by a cutting process and/or by a electroforming process and/or by an electrolytic process and/or by a magnetic moulding and/or moulding and/or extruding and/or an electro-chemical process.

92. The use of a rolling process for forming an information surface into a substantially non-transparent material, said information surface supporting definition of at least a first nano-structure representing information in digital form.

93. The use of a rolling process according to claim 92, wherein the information surface comprises a first nano-structure representing information in digital form.

94. The use of a stamping process for forming an information surface into a substantially non-transparent material, said information surface supporting definition of at least a first nano-structure representing information in digital form.

95. The use of a stamping process according to claim 94, wherein the information surface comprises a first nano-structure representing information in digital form.

96. The use of a thermal process for forming an information surface into a substantially non-transparent material, said information surface supporting definition of at least a first nano-structure representing information in digital form.

97. The use of a thermal process according to claim 96, wherein the information surface comprises a first nano-structure representing information in digital form.

98. The use of an etching process for forming an information surface into a substantially non-transparent material, said information surface supporting definition of at least a first nano-structure representing information in digital form.

99. The use of an etching process according to claim 98, wherein the information surface comprises a first nano-structure representing information in digital form.

100. The use of a cutting process for forming an information surface into a substantially non-transparent material, said information surface supporting definition of at least a first nano-structure representing information in digital form.

101. The use of a cutting process according to claim 100, wherein the information surface comprises a first nano-structure representing information in digital form.

102. The use of a cutting process for forming an information surface into a substantially non-transparent material, said information surface supporting definition of at least a first nano-structure representing information in digital form.

103. The use of a cutting process according to claim 102, wherein the information surface comprises a first nano-structure representing information in digital form.

104. The use of a magnetic moulding process for forming an information surface into a substantially non-transparent material, said information surface supporting definition of at least a first nano-structure representing information in digital form.

105. The use of a magnetic moulding process according to claim 104, wherein the information surface comprises a first nano-structure representing information in digital form.

106. The use of a moulding process for forming an information surface into a substantially non-transparent material, said information surface supporting definition of at least a first nano-structure representing information in digital form.

107. The use of a moulding process according to claim 106, wherein the information surface comprises a first nano-structure representing information in digital form.

108. The use of an extruding process for forming an information surface into a substantially non-transparent material, said information surface supporting definition of at least a first nano-structure representing information in digital form.

109. The use of an extruding process according to claim 108, wherein the information surface comprises a first nano-structure representing information in digital form.

110. The use of an electro-chemical process for forming an information surface into a substantially non-transparent material, said information surface supporting definition of at least a first nano-structure representing information in digital form.

111. The use of an electro-chemical process according to claim 110, wherein the information surface comprises a first nano-structure representing information in digital form.

112. An optical storage medium comprising:

- a substrate,
- an information surface being associated with the substrate, and
- at least one compensating layer positioned between the information surface and an outer surface of the medium changing a phase of a propagating electromagnetic wave front according to a first phase function so as to adapt the optical storage medium to

be read or recorded by a detector/emitter being pre-set to read or record information at an information surface through a medium changing the phase of a propagating wave front according to a predetermined phase function,

wherein the first phase function is different from the predetermined phase function.

113. An optical storage medium comprising:

- a substrate,
- at least one information surface positioned at at least a first distance from an outer surface of the medium, and
- a compensating layer positioned between the outer surface and the information surface for compensating for the at least first distance being different from a predetermined distance by optically reducing a spot size of an light beam incident on the information surface.

114. An optical storage medium comprising:

- a substrate,
- at least one information surface positioned at at least a first distance from an outer surface of the medium, and
- a compensating layer positioned between the outer surface and the information surface for compensating for aberrations caused by the at least first distance being different form a predetermined distance.

115. An optical storage medium comprising:

- a substrate, and
- at least one information surface positioned at at least a first distance from an outer surface of the medium,

wherein the information surface comprises information in the form of a deep surface relief, having a profile being larger than a predetermined profile whereby correction of aberrations caused by the at least first distance being different from a predetermined distance is obtained.

116. An optical storage medium according to claim 115, wherein the deep surface relief comprises pits having a pit depth between 0,5μm and 10μm.

117. An optical storage medium according to claim 115, wherein the deep surface relief acts as an artificial dielectric surface.

118. An optical storage medium according to any of claims 112-117, wherein an information surface comprises information in digital form.

119. An optical storage medium according to any of claims 112-118, wherein the information surface supports definition of at least a first nano-structure representing information in digital form.

120. An optical storage medium according to any of claims 113-115, wherein the predetermined distance is 1,2 mm.

121. An optical storage medium according to claim 113-115, wherein the predetermined distance is 0,6 mm.

122. An optical storage medium according to any of the claims 112-121, wherein the compensating layer comprises an interference filter.

123. An optical storage medium according to claim 122, wherein the interference filter comprises a transmission filter.

124. An optical storage medium according to claims 122 or 123, wherein the interference filter comprises a reflection filter.

125. An optical storage medium according to any of claims 122-124, wherein the interference filter comprises a low pass filter.

126. An optical storage medium according to any of claims 122-125, wherein the interference filter comprises a high pass filter.

127. An optical storage medium according to claims 123 or 124, wherein the transmission/reflection characteristic is selected to be within +/- 20 nm of a centre wavelength.

128. An optical storage medium according to claims 125 or 126, wherein the transmission/reflection characteristic of the high pass/low pass filter is selected to have a transition slope being less than 20 nm.

129. An optical storage medium according to any of claims 112-128 claims, wherein the compensating layer comprises liquid crystal materials.

130. An optical storage medium according to any of claim 112-129, wherein the information surface is read or recorded through the substrate.

131. An optical storage medium according to any of claims 112-129, wherein the information surface is read or recorded through the compensating layer.

132. An optical storage medium according to any of claims 112-131, wherein the compensating layer comprises multiple layers.

133. An optical storage medium according to claim 132, wherein the multiple layers comprises alternating layers having high and low refractive indices, respectively.

134. An optical storage medium according to claim 133, comprising alternating layers of TiO_2 and SiO_x.

135. An optical storage medium according to any of claims 132-134, wherein the thickness of the multiple layers corresponds to 1/4 of a predetermined wavelength (L).

136. An optical storage medium according to any of claims 133-135, comprising a number of alternating layers of TiO_2 and SiO_x, being interconnected via an intermediate layer.

137. An optical storage medium according to claim 136, wherein the thickness of the intermediate layer corresponds to a predetermined wavelength (4L)

138. An optical storage medium according to claim 133-, wherein the alternating layers comprises polyester and acrylic.

139. An optical storage medium according to any of claims 112-138, wherein the compensating layer comprises optical birefringent material.

140. An optical storage medium according to claim 139, wherein reflectivity of the compensating layer for p-polarized light is controlled by controlling the birefringent properties of the birefringent material.

141. An optical storage medium according to claim 139, wherein Brewsters angle of the compensating layer is controlled by controlling the birefringent properties of the birefringent material.

142. An optical storage medium according to any of claims 112-141, wherein the information surface is formed in the substrate.

143. An optical storage medium according to any of claims 112-141, wherein the information surface is formed in a film layer deposited on the substrate.

144. An optical storage medium according to any of claims 112-143, further comprising a buffer layer between the substrate and the film layer.

145. An optical storage medium according to claim 144, wherein the film layer is reflective.

146. An optical storage medium according to claim 143, wherein the film layer is covered by a reflective layer.

147. An optical storage medium according to any of claims 112-145, wherein the film layer comprises a reflection filter.

148. An optical storage medium according to any of claims 112-147, wherein the substrate comprises at least a material selected from the group consisting of metal, glass, polymers, elastomers, paper, cardboard, wood or any combination thereof.

149. An optical storage medium according to any of claims 112-147, wherein the substrate comprises at least one material selected from the group consisting of polyester, polystyrene, PMMA, PS, PP, PE, PET, APET, ABS, HIBS, PC and acrylic

150. An optical storage medium according to any of claims 112-149, wherein the film layer and/or the reflective layer is coated by a protective layer.

151. An optical storage medium according to any of claims 112-150, further comprising a planarising layer.

152. An optical storage medium according to claim 151, wherein one layer comprises the protective layer and the planarising layer.

153. An optical storage medium according to any of claims 112-152, wherein the thickness of the compensating layer is 0,5μm - 200μm, such as 1-50μm.

154. Use of an optical storage medium according to any of claims 112-153 in a standard optical playback device.

155. Use of an optical storage medium having a thickness of less than 1,1 mm in a standard optical playback device.

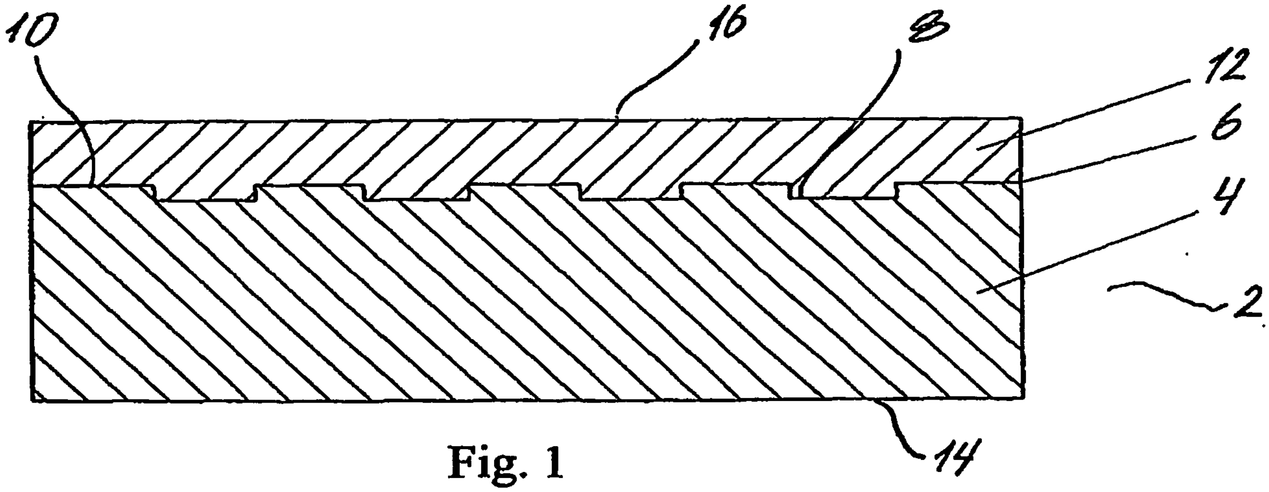

Fig. 1

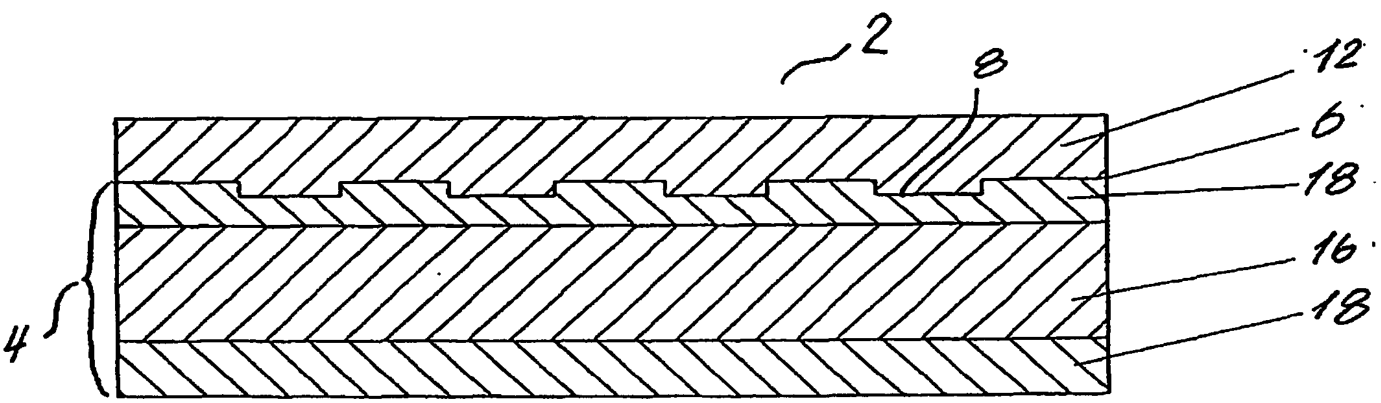

Fig. 2

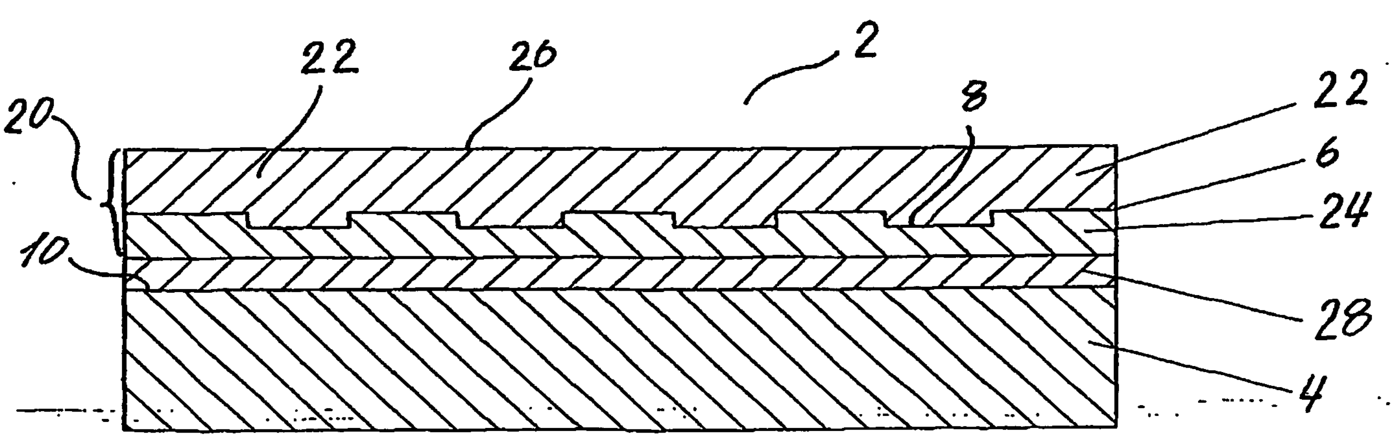

Fig. 3

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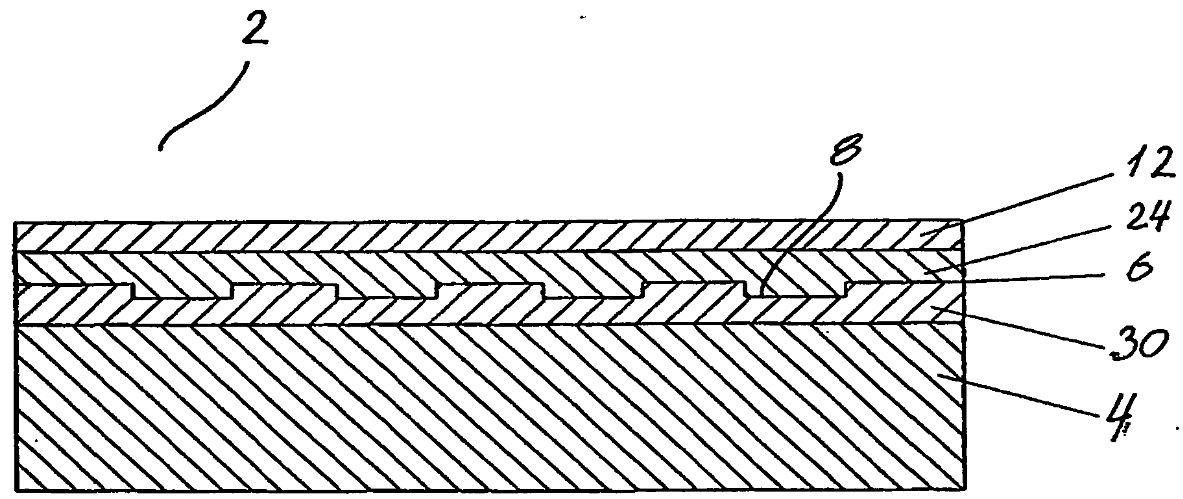

Fig. 4

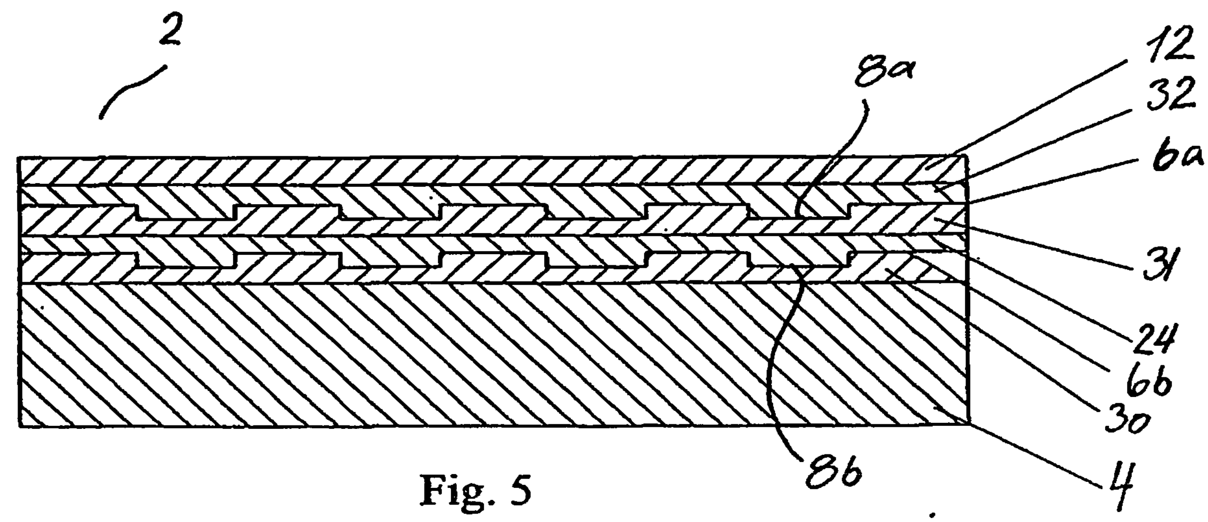

Fig. 5

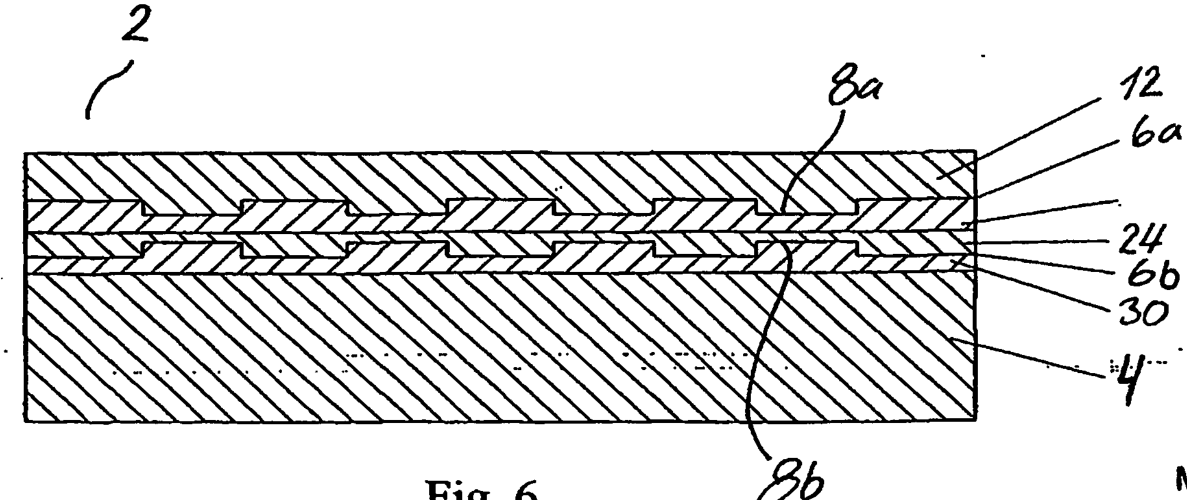

Fig. 6

Fig. 7

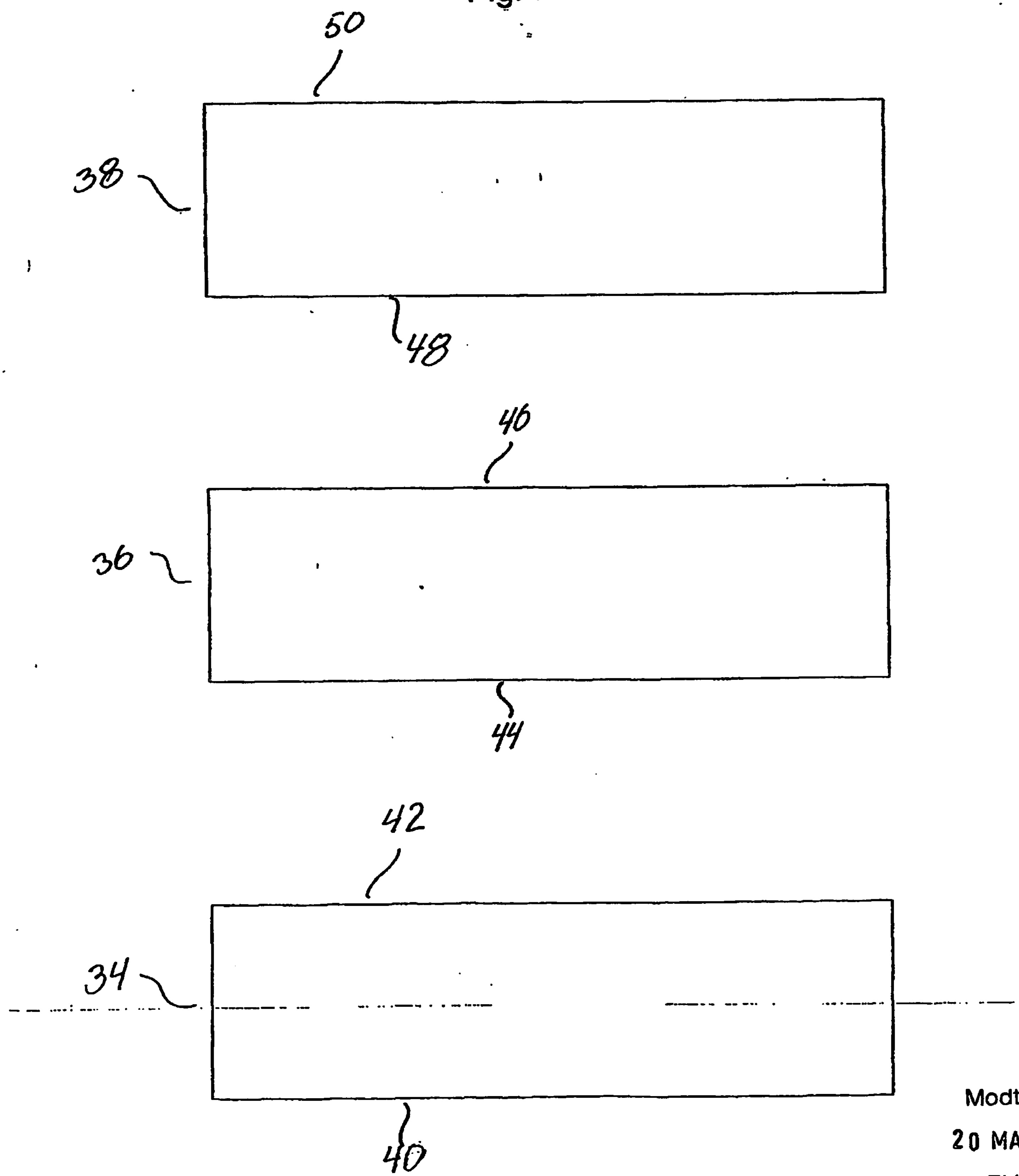

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Fig. 8a

Fig. 8b

Fig. 8c

Fig. 8d

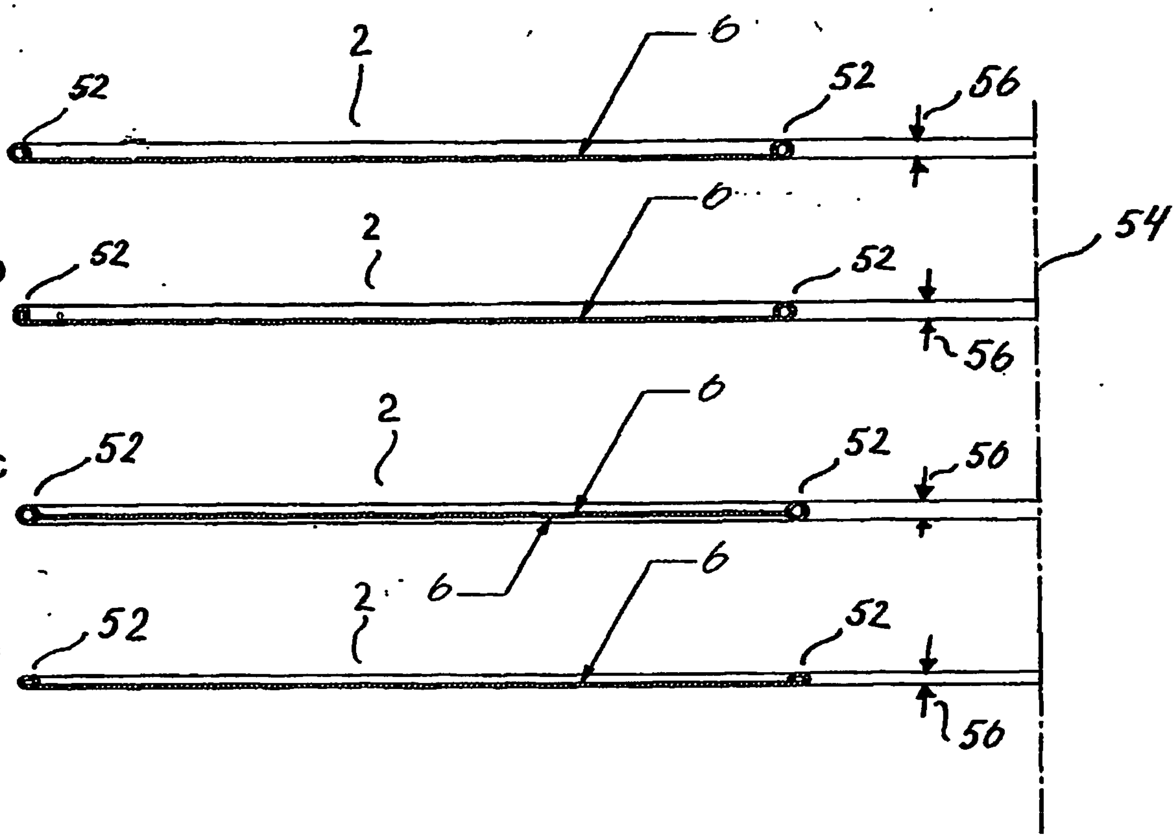
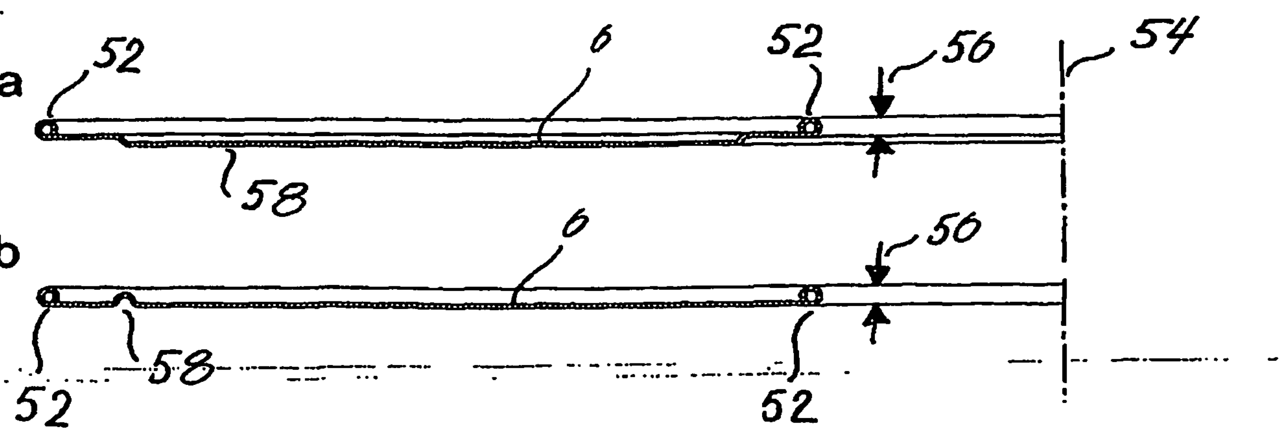


Fig. 9a

Fig. 9b



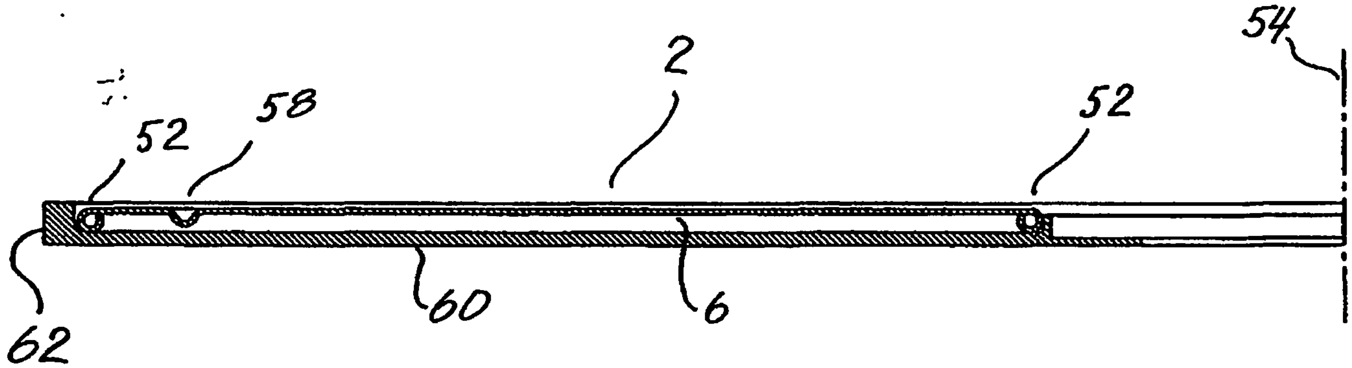


Fig. 10a

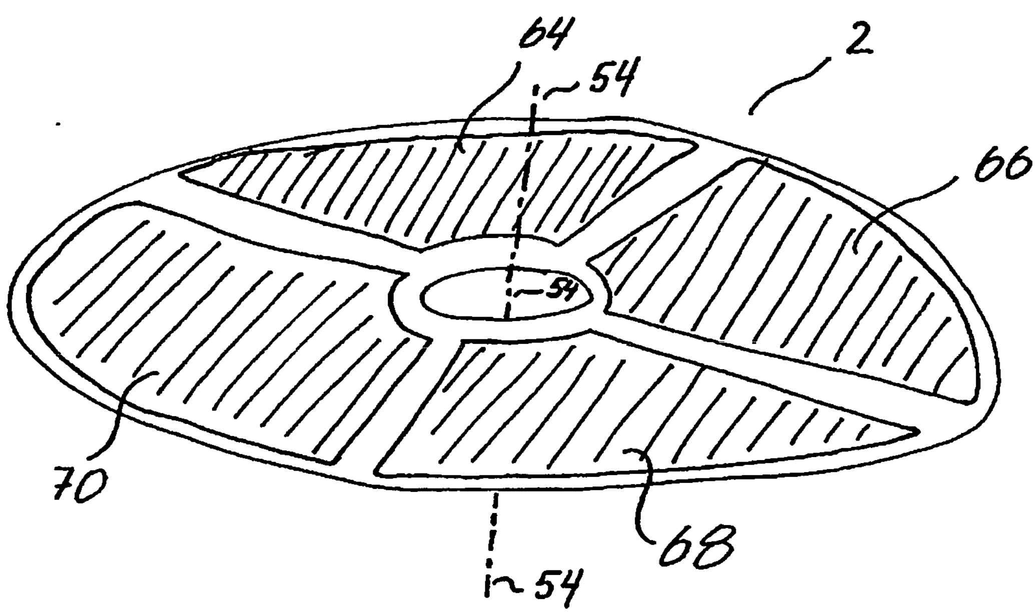


Fig. 11

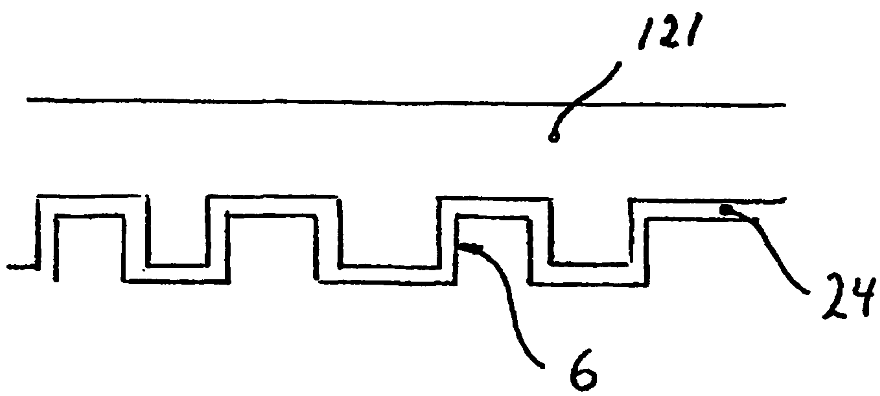


Fig. 12

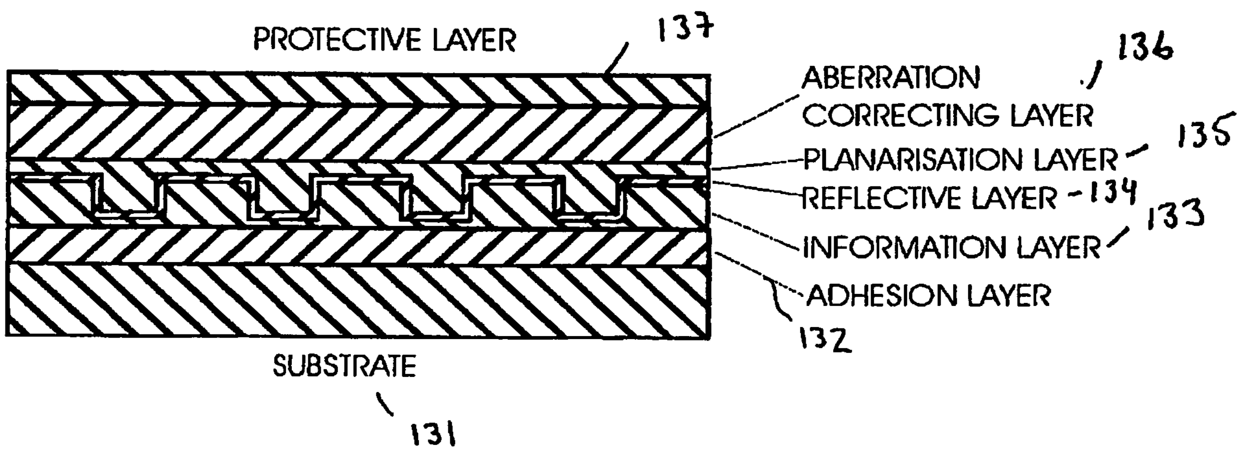


Fig. 13

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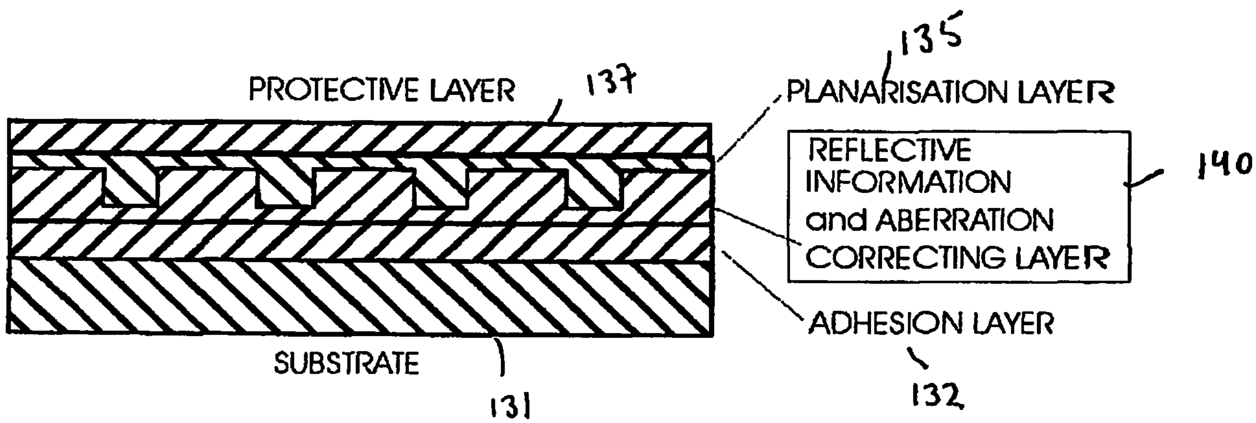
135
PROTECTIVE LAYER
137
PLANARISATION LAYER
REFLECTIVE
INFORMATION
and ABERRATION
CORRECTING LAYER
140
ADHESION LAYER
SUBSTRATE
131
132

Fig. 14